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Drug regulations and trafficking: Synthetic cannabinoids and cathinones in Hungary

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ABSTRACT

In principle, new psychoactive substances (NPSs) are produced to circumvent drug regulations. However, the mixed success of regulatory efforts suggests that the dynamics of marketing is incompletely understood. To address this issue, we conducted a comprehensive study on the marketing of all synthetic cannabinoids and cathinones present in Hungary over ten years. Market evaluation was based on drug seizure data and chemical analyses provided by the Hungarian Institute for Forensic Sciences. Over ten years, 18 synthetic cannabinoids and 11 cathinones were identified. Total seizure counts were 22,906 and 10,273, respectively. When new synthetic cannabinoids emerged, seizures increased exponentially, but rapidly declined after their banning. In parallel, new synthetic cannabinoids emerged on the market. The systematic monitoring of local legislation allowed large sales between market introduction and legal control. Cathinones were also marketed in successive waves, but trading intensity was not associated with local regulations. Sales remained low throughout, likely because the risks involved by the temporal mismatch between marketing and legal control. One can hypothesize that marketing was driven by general trends in EU regulations or by measures taken by large countries. Our findings imply the existence of two different strategies for NPS marketing. The choice between the two may depend on multiple factors from the availability of skills required by rapid marketing adjustments to cost/benefit evaluations for various market segments. Studying NPS market strategies in neighboring and distant EU countries may help analyzing and predicting market events.

1. Introduction

Most designer dugs, including synthetic cannabinoids and cathinones have a large addiction potential and can lead to various diseases, including cardiovascular and respiratory complications, haemodynamic embarrassment, renal injury and cerebrovascular accidents (synthetic cannabinoids) as well as cardiac, metabolic, neuropsychiatric and neurological complications (cathinones) [1,2]. Moreover, both synthetic cannabinoids [3] and cathinones [4] can cause death. However, the large number, chemical diversity, and rapid emergence of new variants make it difficult to detect, monitor, and develop appropriate responses to them [5,6]. For instance, the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) recorded hundreds of new designer drugs over the first 20 years of the century, yet the number of substances present on the illicit market at any given time is only a fraction of this number, because drugs replace each other rapidly. This dynamic of the market is incompletely understood, especially in relatively small countries like Hungary.

Both categories of substances emerged on the EU market at the beginning of the 21st century and are tightly and frequently monitored by both the EMCDDA and Europol. Yet these agencies focus on the identification of new substances, as well as on their market sizes, country profiles, health risks, etc., paying less attention to their market fate, e.g., drug lifetime on the market, and drug turnover [7–9]. A recent study performed in New Zealand addressed this issue and showed that new substances are present on the market usually for 1–2 years only, and even within this short period the market size of competing substances undergoes major changes [10]. Similar trends can be deduced from data provided by the US Drug Enforcement Administration [11–14] although the issue was not investigated in detail so far.

Another little-known aspect of marketing relates to the impact of drug control regulations. Naturally, new designer drugs are introduced because the previous ones were banned after their detection on the market. However, the findings of earlier studies were mixed in this respect. It was reported that banning decreased trafficking [15,16]. However, other studies found that regulations had no effect [17,18]. In a Hungarian study, milder regulatory measures, e.g., listing the substance

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as a new psychoactive substance did not affect sales, whereas listing it as an illicit drug durably decreased its market presence [19]. Noteworthy, the term "new psychoactive substance" is a legal label in Hungary, which explains why we used in the followings the term designer drug rather than the more conventional expression new psychoactive substance. The Hungarian "new psychoactive substance" status involves shorter prison sentences for marketing than for illicit drug status and in addition, the possession of small amounts of new psychoactive substances is a misdemeanor in Hungary, whereas the same is a criminal offense with illegal drugs. The complexity of the relationship between regulatory measures and marketing was outlined by a study performed in Australia, where bans based on chemical names had little impact on trafficking, whereas banning brand names was followed by a sustained decrease [20]. These findings suggest that the efficacy of legal measures depends on a variety of factors, including the scheduling class and the intelligibility of legal terms for traders and consumers.

The relationship between regulatory measures and drug trafficking is complicated by the fact that local regulatory measures are not synchronized within the EU. As an example, the new synthetic cannabinoid 4 F-MDMB-BICA was banned in 7 EU countries by the end of 2020, 16 countries took no measures, whereas other five implemented milder restrictions [8]. In a similar fashion, the cathinone 3-MMC was under control in Italy already in 2014, but remained unregulated in most other EU countries in that year [21]. Thus, the very same substance may be legally risky in some countries, whereas in others it may be marketed with minimal risks. How do the distributors of synthetic cannabinoids and cathinones handle such a mosaic of local regulations in EU countries?

To get insights into the issue, we tracked the market presence of synthetic cannabinoids and cathinones in Hungary over 10 years. The drug market was studied by means of drug seizures by the police. Although seizure counts are indirect indicators of marketing, forensic data were often used to evaluate drug trafficking and to provide insights into illicit drug markets [10,22,23]. Noteworthy, it was demonstrated in a Hungarian study that the number of positive drug tests for a given substance correlated significantly with the number of police seizures concerning that substance [19]. To address the impact of regulations, we studied trafficking data in conjunction with legal measures. We hypothesized that the distributors of new designer drugs adapt to the regulation of the largest markets; consequently, they must bear legal risks in smaller countries where the introduction of regulatory may have a different time-course. Alternatively, regulatory measures are followed in all market segments, i.e., specifically in all countries irrespective to their size, in which case distributors must follow a country-specific strategy.

2. Materials and methods

2.1. Data source

Here we studied the database of the Drug Investigation Department, Hungarian Institute for Forensic Sciences (Budapest). According to the Government Decree 282/2007, this is the only Hungarian institute authorized to examine substances seized by the police. Samples came from all over Hungary. For this study we selected all seizures where analysis indicated the presence of either synthetic cannabinoids or cathinones.

The Hungarian Institute for Forensic Science follows the European Network of Forensic Science Institutes' Best Practice Manual for controlled drug analysis [24]. The main steps of the protocol for analysis are as follows. Plant materials are analyzed first by gas chromatography-mass spectrometry (GC-MS). If the result of the analysis was positive, Δ9-THC, psilocybin, and opiates are reanalyzed by thin layer chromatography. In all other cases, the second analysis is FTIR (attenuated total reflection Fourier transform infrared spectroscopy). In certain cases, other techniques were also employed, e.g., HPLC-DAD (high-performance liquid chromatography with diode-array detection), GC-IS (GC-infrared spectroscopy), HPLC-MS, and NMR (nuclear magnetic resonance). Powders and tablets were evaluated first by FTIR, followed by GC-MS. If this was inconclusive, HPLC-DAD, GC-IRD (gas chromatography with infrared detection), HPLC-MS, or NMR were employed. Substances were positively identified only if two different methodologies provided similar results. We present below the two main methods of analysis.

For GC–MS analysis, 1–5 mg of powder samples, and approximately 10 mg of plant material was extracted in 1 ml of methanol. Samples were analyzed by Agilent 6890NGC system coupled to an Agilent 5973 N Mass Selective Detector and 7890 A/5975 C, 8890/5977B systems (Agilent Technologies, Santa Clara, California, USA). Samples were subjected to electron ionization. Split mode was employed with a split ratio of 60:1, and a split flow rate of 80 ml/min. The injection volume was 1 μl, with helium as the carrier gas. The column flow was 1,5 ml/min. The temperatures of the ion source, the quadrupole and the injector were 230, 150 and 300 °C, respectively. The starting temperature of the oven was 100 °C which was held for 2 min; subsequently, it was heated to 280 °C at an increase rate of 20 °C/min. This temperature was held constant for 3 min, after which it was increased to 315 °C at an increase rate of 25 °C/min. The temperature was held constant at 315 °C for 12 min. The electron impact mass spectra were recorded using total ion monitoring (scan range of 35 up to 500 *m/z*), with an EI voltage of 70 eV. Chromatographic separation was achieved using an Agilent HP-5MS column (30 m x 0.25 mm ID x 0.25 μm film thickness). Tribenzyl-amine 0,1 mg/ml was applied as an internal standard (locked with RT lock to 10,8 min). Data handling was carried out with GC/MSD ChemStation software (Agilent Technologies, Santa Clara, California, USA). For FTIR, the sample was extracted with acetone. The infrared spectrum was recorded on a Bruker Tensor 27 IR spectrometer (Bruker, Rheinstetten, Germany) equipped with a Platinum ATR accessory, in absorbance mode. The sized powder was measured directly. Scanning ranges were 4000 cm-1 and 600 cm-1 with a digital resolution of 4 cm-1 for 32 scans. The spectrometer was controlled, and the data were processed using Opus 6.5 software package (Bruker, Rheinstetten, Germany).

2.2. Data analysis

Statistics were made by the STATISTICA software (TIBCO Software Inc, USA). Seizure data were evaluated by two-factor ANOVA; Factor 1 was the drug class (levels: synthetic cannabinoids and cathinones) whereas Factor 2 was time (levels: the month of market presence). Data fulfilled ANOVA requirements; therefore, they were not transformed. Post-hoc comparisons were made by the Duncan test. Bonferroni correction was employed throughout. P values lower than 0.05 were considered significant. P values between 0.1 and 0.05 were interpreted as trends.

3. Results

3.1. Trafficking data

In the investigated period, 18 synthetic cannabinoids and 11 cathinones were identified in samples collected by police; the number of cannabinoid seizures were almost two times larger than those of cathinones (Table 1). For their chemical structures see Figs. 1 and 2. During the 10 years investigated, new variants of synthetic cannabinoids emerged every 6–7th month, whereas new cathinones emerged on a yearly basis (Figs. 3 and 4). On average, each substance was present on the market for about 2.5 years (29.5 ± 3.1 month). Note that substances were seized following these 2.5 years, but seizures in this period were sporadic (1–2 seizures every second or third month). No more

Table 1
Synthetic cannabinoids and cathinones seized in the investigated period.

Substance name	*Total seizures (counts)*	*Succession order*
Synthetic cannabinoids		
5 F-MDMB-PINACA	3674	13
AB-CHMINACA	2613	9
ADB-FUBINACA	2297	8
5 F-MDMB-PICA	2124	15
AMB-FUBINACA	2075	14
AKB-48 F	1812	3
MDMB-CHMICA	1593	11
AM-2201	889	1
PB-22	809	4
AB-PINACA	763	6
AB-FUBINACA	706	7
MDMB-4en-PINACA	658	17
5 F-AMB	678	10
PB-22 F	587	5
5-FUR-144	560	2
ADB-PINACA	450	12
4 F-MDMB-BINACA	434	16
4 f-MDMB-BICA	184	18
Total seizures	*22,906*	
Cathinones		
Pentedrone	2636	4
Ethylhexedrone	2444	9
α-PVP	1057	5
Mephedrone	836	1
4-MEC	724	3
MDPV	609	2
4-CMC	500	7
3-MMC	420	6
Ethylheptedrone	365	11
4Cl-PVP	356	10
α-PHP	326	8
Total seizures	*10,273*	

Succession order refers to the date of the first occurrence of the substance in samples. For the chemical structure of substances see Figs. 1 and 2.
Note. All figures are 2-column fitting images.

than 5 – usually fewer – new substances of the same category were present in significant quantities on the market concurrently. Thus, new substances replaced earlier ones in a rather regular fashion.

The sample counts of a particular substance did not show significant correlations with the succession order of its introduction (Table 1; synthetic cannabinoids: $R = -0.135$; $p > 0.5$; cathinones: $R = 0.509$; $p > 0.1$). As such, the reason for substance succession did not seem to be related to improved attractiveness, which may be explained, e.g., by an optimization process from the side of synthesizers or traders. In other words, substance succession did not seem to be related to a product development or improvement process.

Typically, synthetic cannabinoids were not yet regulated when first discovered in police samples, and the number of seizures rapidly increased until they were declared new psychoactive substances after 6.0 ± 0.7 month on average (Fig. 3). Seizure counts rapidly decreased thereafter with each substance. Some substances remained on the market after their regulation, but seizure numbers in this period were usually low. The situation with cathinones was somewhat different, although these substances also emerged sequentially, and like cannabinoids, their marketing was performed in waves that were preceded and followed by silent periods with very low or no seizures. However, there was no clear relationship between regulatory measures and the marketing of these substances (Fig. 4).

3.2. Regulations and drug trafficking

To investigate the impact of regulations on trafficking in more detail, we superimposed the date of the first regulatory measure for all substances (Fig. 5 A). Monthly seizure numbers of all substances belonging to either of the two drug types depended on the interaction between the drug type and time ($F_{interaction}$ (53, 1431) = 3.01; $p < 0.0001$). The average seizure counts of synthetic cannabinoids exponentially increased until they were declared new psychoactive substances, which was followed by a rapid decline. Thereafter, synthetic cannabinoid seizures remained low. The seizure counts of cathinones also increased after their emergence on the market (F_{time} (53,1431) = 4.52; $p < 0.0001$), but never increased to the level seen with synthetic cannabinoids (Fig. 5 A). On the contrary, seizure counts remained low and were rather stable throughout their presence on the market. Synthetic cannabinoids and cathinones were different only during the dramatic increase and decrease with the former, which surrounded the timing of the first regulatory measure (Fig. 5 A).

After the substances were declared illicit drugs, which had more serious consequences for dealers than the "new psychoactive drug" status, drugs gradually disappeared from seizures (Fig. 5B). The two drug types were statistically similar in this regard.

3.3. Reactive and preemptive regulation

Most cannabinoids (83%) and almost half of cathinones (45%) were declared new psychoactive substances reactively, i.e., as a response to their emergence on the market. Preemptive regulation, i.e., implementing regulations before the drug emerged on the market, was employed with 17% of cannabinoids and 55% of cathinones. To investigate the impact of the timing of the regulatory measures, we re-evaluated the data by considering these two regulatory strategies.

In the case of reactive regulation, again, there was a significant interaction between the drug type and time ($F_{interaction}$ (53, 954) = 1.51; $p < 0.01$). The marketing of synthetic cannabinoid was, whereas the marketing of cathinones was not influenced by the implementation of regulations, e.g., their listing among new psychoactive substances (Fig. 6 A). Preemptively controlled substances emerged on the market about 2 years after the regulatory measure, and seizure numbers remained low and relatively stable thereafter (Fig. 6B). The number of seizures appeared larger with synthetic cannabinoids ($F_{interaction}$ (54, 378) = 2.23; $p < 0.01$). However, the difference did not survive Bonferroni correction in post hoc comparisons, likely because the difference between the two drug types was exclusively due to the surprisingly high number of seizures of the cannabinoid 5 F-MDMB-PICA (Fig. 6B insert). Although declared a new psychoactive substance long before its introduction to the Hungarian market, it reached trafficking levels similar to other synthetic cannabinoids when these were not yet regulated.

4. Discussion

4.1. Main findings

New synthetic cannabinoids and cathinones emerged regularly on the Hungarian market over the ten years investigated. The marketing of new substances rapidly increased after their introduction, and rapidly declined after reaching a peak. Parallelly with this decrease, a new substance emerged on the market.

The succession order of compounds depended neither on their popularity as judged from sample counts (see Results) nor on their biological efficacy. For instance, 5 F-MDMB PICA was more efficacious than MDMB-4en-PINACA, which emerged on the market almost 2 years later, whereas AB-FUBINACA, which emerged 4 years earlier was less efficacious [25]. Similarly, 4 f-MDMB-BICA, which was the last in the time series, was less potent than 4 F-MDMB-BINACA, whereas 5 F-MDMB-PICA was more potent than AM-2201, which was the first in the time series [26,27].

The two drug classes differed regarding the relationship between regulatory measures and marketing. With synthetic cannabinoids, mar-

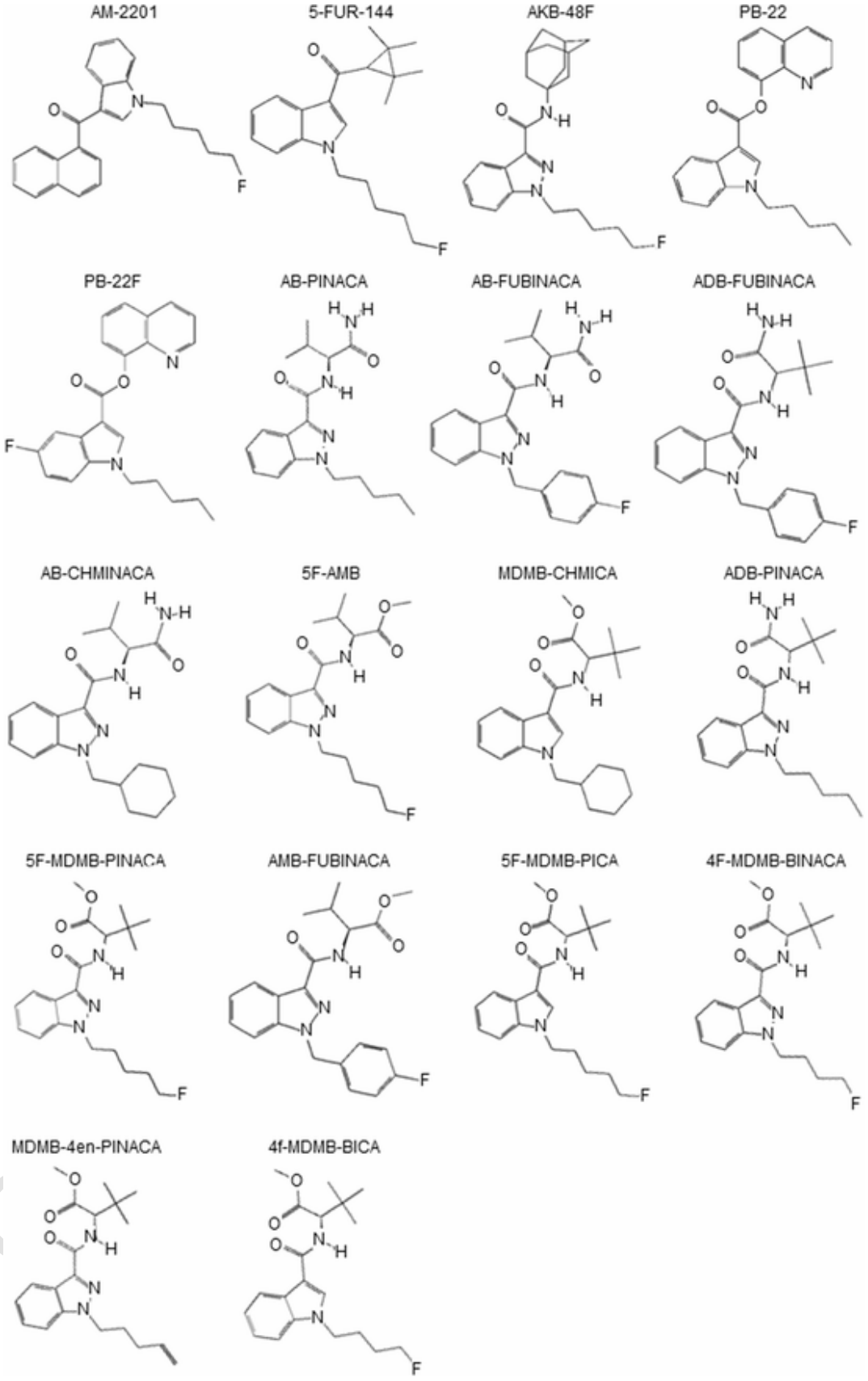

Fig. 1. The chemical structure of synthetic cannabinoids seized in Hungary in the investigated period.

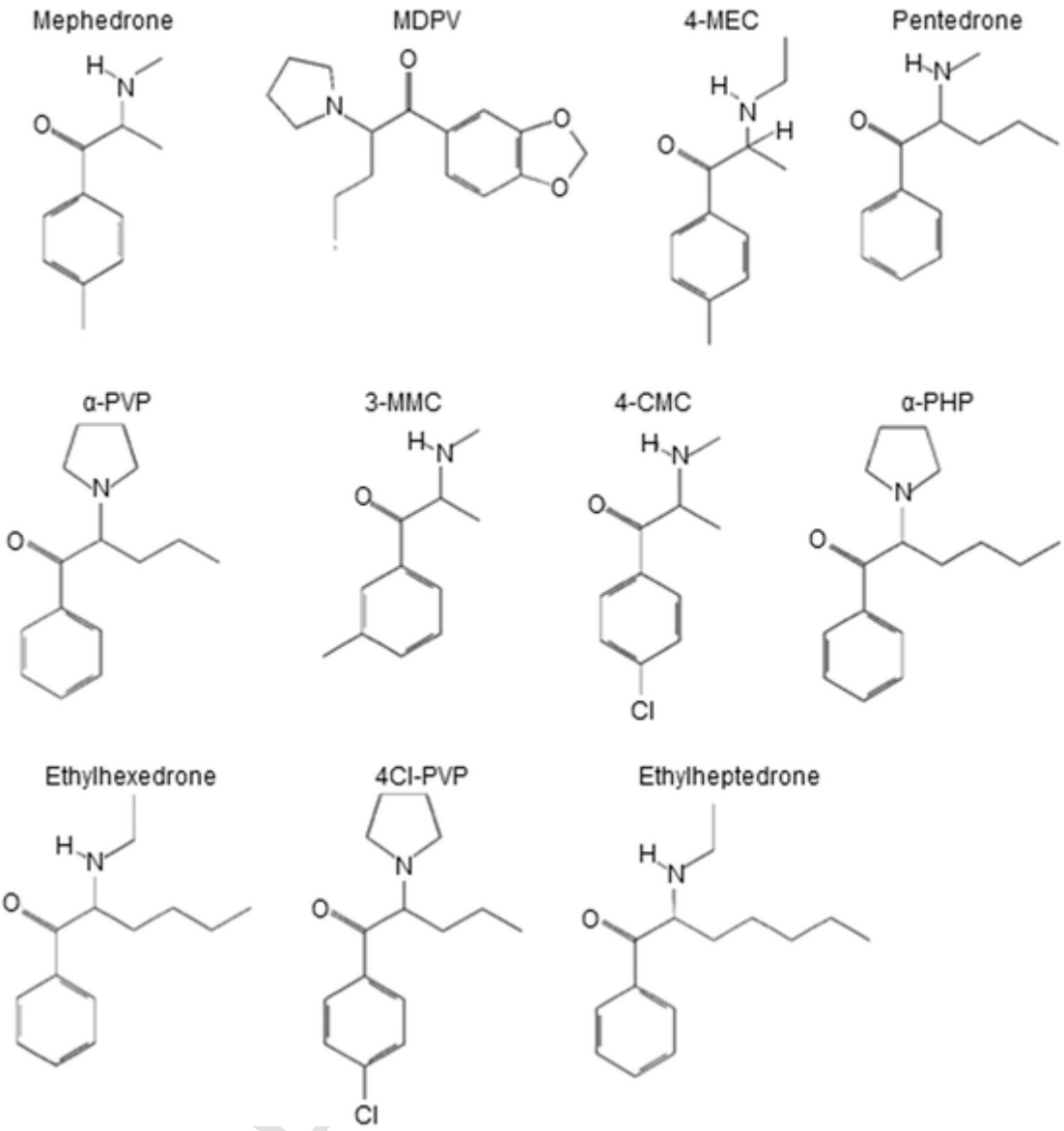

Fig. 2. The chemical structure of cathinones seized in Hungary in the investigated period.

keting quickly responded to even mild regulatory measures, e.g., to their listing as new psychoactive substances. By contrast, the marketing of cathinones did not depend on this milder regulatory measure. The listing of substances as illicit drugs led to their gradual and slow disappearance from the market. Synthetic cannabinoids and cathinones were similar in this respect.

Our data suggest that the organizations that distributed synthetic cannabinoids in Hungary consciously monitored the country's drug regulations, and by this managed to exploit those periods, which were relatively safe for trafficking. As the temporal patterns of drug seizure were similar with the two types of substances, only their relationship with Hungarian legislation differed, we hypothesize that cathinone marketing followed the regulations of other markets.

4.2. The marketing of synthetic cannabinoids and cathinones

Both synthetic cannabinoids and cathinones are regularly seized in various parts of the world. Yet, there are important differences regarding the substances that are sized. For instance, the main synthetic cannabinoids and cathinones seized in Siberia or South Korea [28,29] were not detected in Hungary. Overlaps between the main substances seized were few even with Turkey and Hungary, which are considerably closer geographically [30].

The EU market is more uniform in this respect, likely because the putative location of synthesis, e.g., China and the route by which substances reach the continent, e.g., Belgium and the Netherlands are similar for all or most EU countries [5,9]. While the substances per se are rather similar, their distribution patterns remain different. For instance, 5 F-MDMB-PINACA was reported first in Hungary in 2015, where the number of seizures remained the highest till the end of 2017; Hungary was followed by Turkey, and Sweden [31]. By contrast, AB-CMINACA was first reported in Latvia in 2014 and reached its highest peak in Turkey and Poland in 2016 and 2017 [32]. Similar differences were observed with cathinones as well. The most frequently seized cathinone in the EU was ethylhexedrone in 2017 [9], which was only the second in Hungary, while pentedrone, the most popular substance in Hungary, was infrequently seized in other EU countries [9]. In addition, cathinones were more popular than synthetic cannabinoids in Italy [21], whereas we observed the reverse in Hungary. Irrespective to the country, however, the rapid turnover of substances is typical in the EU and other countries, which makes their control difficult [33,34].

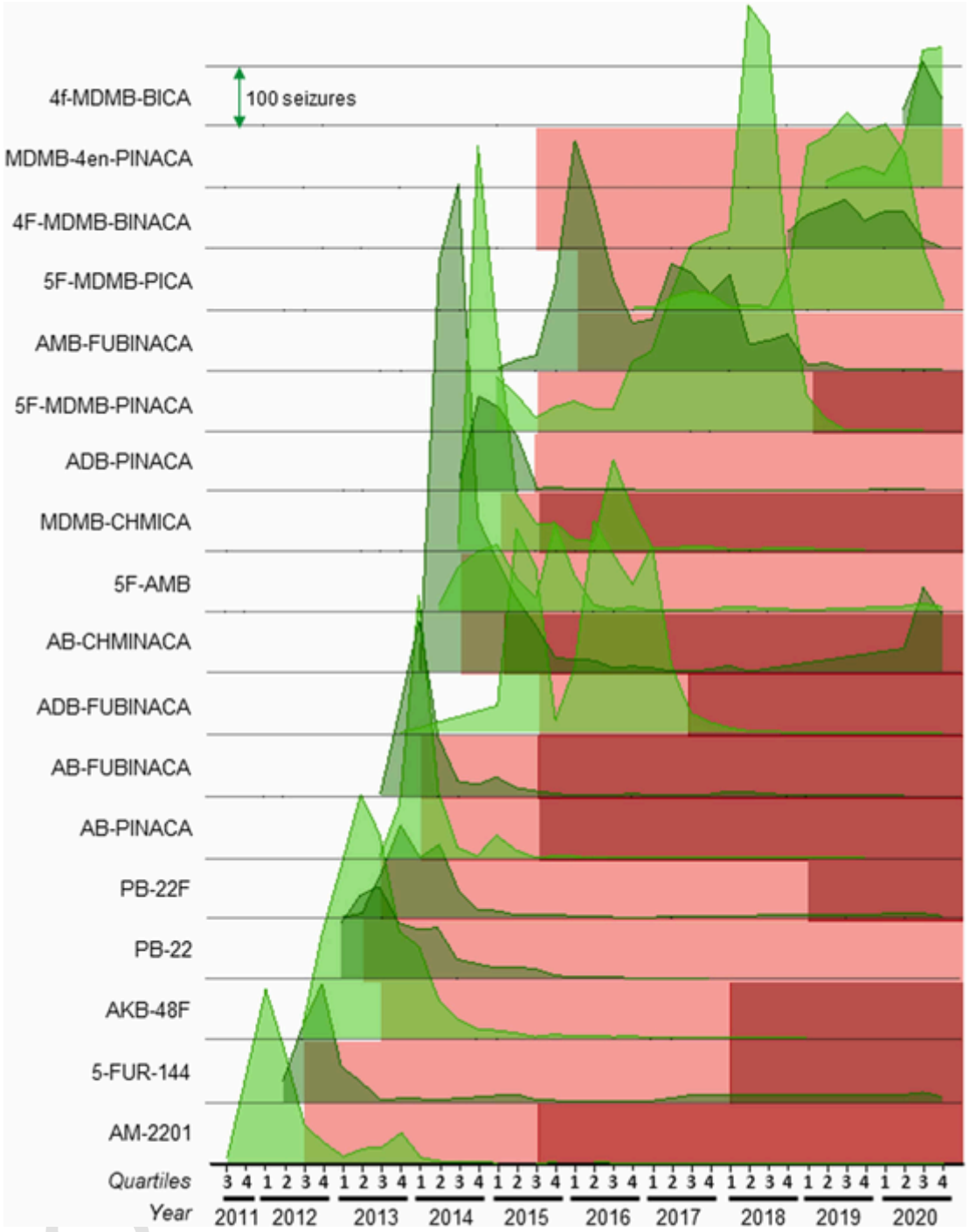

Fig. 3. *Synthetic cannabinoid seizures in Hungary over 10 years*. Drug seizures were presented in chronological order (see X-axis). The number of seizures (solid green curves) was presented on a quarterly basis for each drug shown next to the Y-axis, which was collapsed to fit all drugs in one figure. The distance between horizontal lines corresponds to 100 seizures. The rows of the figure also indicate the legal status of the substances. *White*, not controlled; *light pink*, listed as new psychoactive substance; *dark pink*, listed as illicit drug.

The reasons underlying the differential dynamics of drug marketing are likely multiple, but our findings suggest that differences in local regulatory measures may play a role in this process. As shown in Introduction, the legal status of synthetic cannabinoid and cathinones shows substantial differences across EU member states [8,21]. Thus, the marketing of a substance may be legally risky in some countries, without involving risks in others. Such differences may shape global and local marketing strategies of drug traffickers within the EU.

4.3. Regulations and marketing

Earlier findings on the relationship between regulatory measures and drug marketing were conflicting. In two earlier Hungarian studies, the marketing of the cathinone mephedrone and of stimulant designer drugs in general were decreased when they were listed as illicit drugs, albeit not when listed only as new psychoactive substances [15,19]. Regulatory measures were also effective with the synthetic cannabinoid JWH-018 in Germany [16]. This compound disappeared from the market 4 weeks after its banning and was replaced with its non-regulated

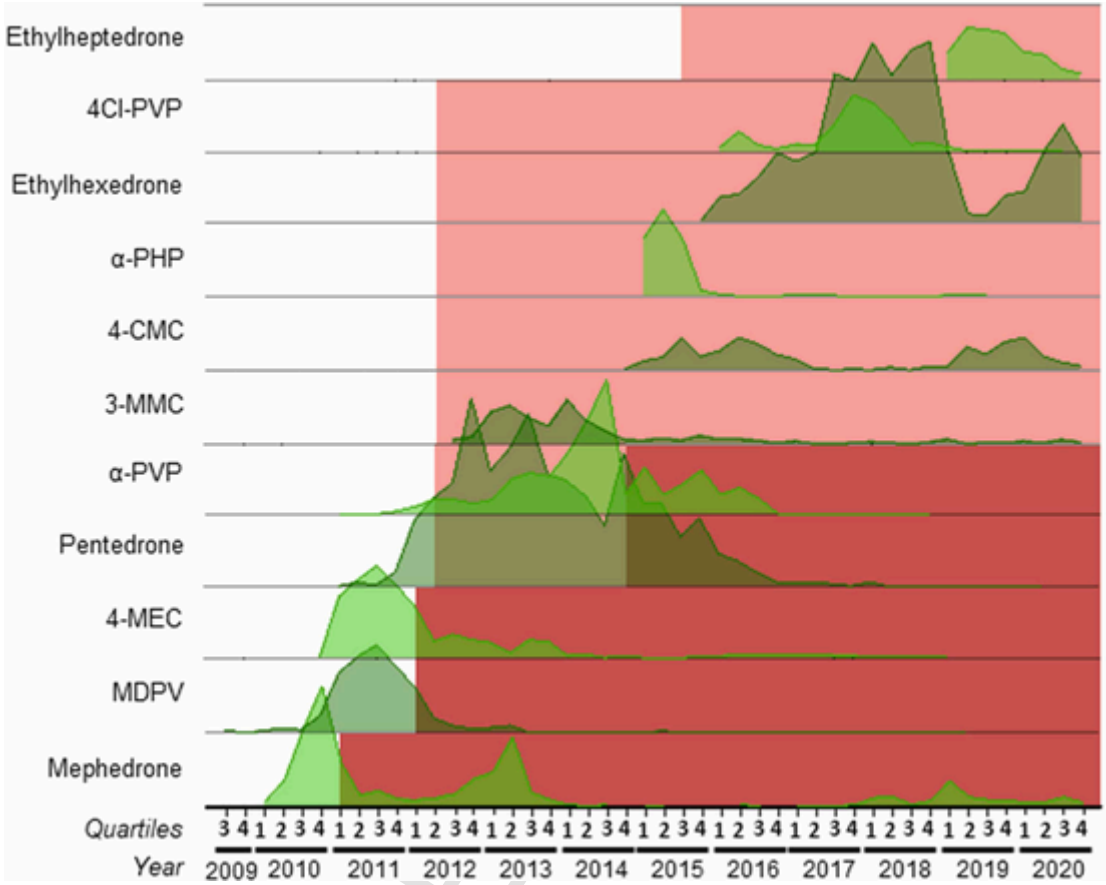

Fig. 4. *Cathinone seizures in Hungary over 10 years*. For details, see the legends for Fig. 1.

homolog JWH-073. By contrast, the synthetic cannabinoid CP 47,497-C8 was still present on the market when JWH-018 disappeared. Positive effects were also observed in Australia and Hungary [20,35]. In Australia, banning specific synthetic cannabinoids or banning all synthetic cannabinoids through a group entry was in fact without effect. However, banning the same compounds by brand names decreased marketing within one month and almost eliminated their marketing within 6 months. The temporal evolution of these events is similar to that observed in our study. By contrast, the banning of synthetic cannabinoids in general had minimal effects in South Korea, the banning of synthetic cannabinoids had no effects in the UK, whereas the banning of various designer drugs also had mixed effects in Taiwan, South Korea, and Japan [17,18,36]. In South Korea, regulations modestly reduced synthetic cannabinoid marketing after one year, but the change was only temporary as it increased again in the following year. A comparative study performed in Japan, South Korea, and Taiwan found that regulations decreased marketing in Japan only. Although not related directly to marketing, it is worth mentioning that the frequency of synthetic cannabinoid intoxications was significantly reduced after the implementation of regulatory measures in Germany [37].

Unfortunately, methodological differences between these studies preclude direct comparisons as it regards the efficacy of regulations. It occurs, however, that in some instances regulations did affect marketing, whereas in other they did not. One reason of this discrepancy might be that suppliers may employ marketing strategies that are different from country to country and may also depend on the compounds.

We found that milder forms of regulation, e.g., the new psychoactive substance status was sufficient to limit the marketing of synthetic cannabinoids but not of cathinones in Hungary. At the same time, the marketing of both substances was stopped by their listing as illicit drugs, although their elimination from the market was a slow, e.g., it lasted 2–3 years. Importantly, preemptive regulation eliminated the escalation of marketing that preceded the regulatory measures in the case of reactive regulation, albeit it did not eliminate distribution altogether.

Our findings suggest that those responsible for the marketing of designer drugs show a differential sensitivity to local regulatory measures. As such, the relationship between marketing and regulation may be specific to the organizations, which are involved in trafficking. More importantly, however, our findings suggest the existence of two different marketing strategies. One strategy, which was illustrated here by synthetic cannabinoids, involves the conscious monitoring of, and adjustment to, local regulatory measures. This allows large sales in the short period that precedes the banning of the substances. Tentatively, traders may even move their activity from one country to another to take advantage of the opportunities created by the unsynchronized regulations within the EU. The other marketing strategy, exemplified here by cathinones, is less sophisticated and may adapt to general EU trends in the regulatory measures, without being specific to individual markets. This involves legal risks and likely for this, this strategy was associated with low sales as compared to cannabinoids.

It remains to be seen how such strategies affect designer drug marketing in neighboring and distant EU countries. Judged from the small number of producing and transit countries (see above) the EU is a global market for designer drugs. As such, revealing the web of regulations/marketing relationships may help understanding how such drugs are marketed at a continental level.

4.4. Limitations

One limitation of our study was that it relied on seizure data, i.e., on an indirect measure of marketing. This approach, however, was employed by several earlier studies and in addition, a Hungarian study

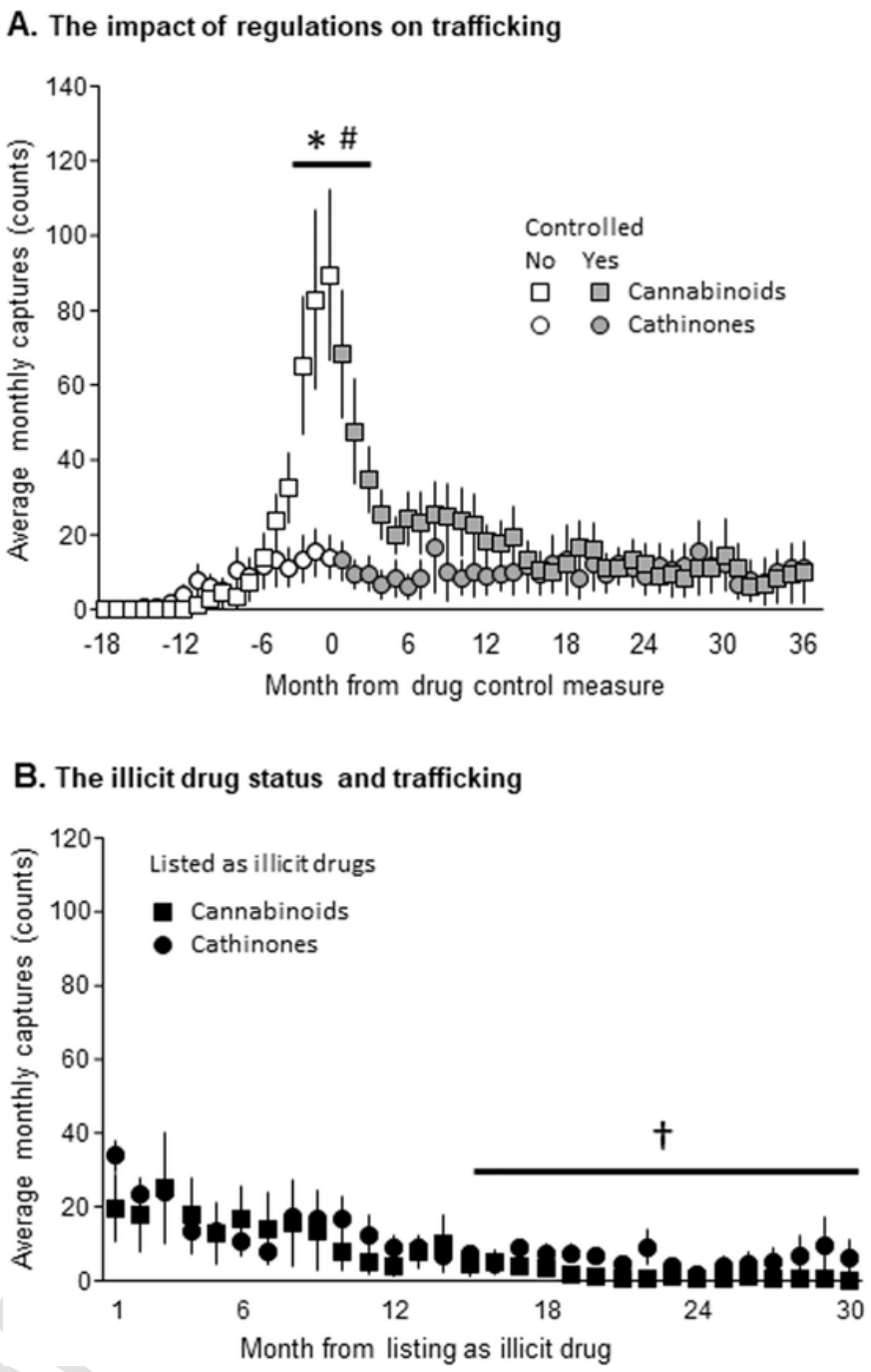

Fig. 5. *The impact of regulations on drug trafficking.* (**A**) The transition from uncontrolled to new psychoactive substance status. The dates of the drug regulation were superimposed. (**B**) Trafficking after the substances were listed as illicit drugs. Post hoc comparisons: * , significantly different from all other time points of synthetic cannabinoid trafficking. Note that no such period occurred with cathinones; # significant cannabinoid-cathinone difference; †, significant decrease from first time-point, both drug types. In all cases, $p < 0.05$ (at least) after Bonferroni correction. For ANOVA see text.

found high correlations between marketing evaluations that were based on blood drug measurements and those based on seizure data [19]. The number of seizures may not be appropriate for establishing drug trafficking in absolute terms but appears suitable for evaluating market trends. Another limitation of this study is that it focused on one single country in a highly interacting geographical area. The totality of evidence briefly reviewed here together with our findings suggest that that the mosaic of local regulatory measures interactively affect local and global trends in the marketing of designer drugs. Establishing the intricate web of such interactions remains for future studies. Presently, we recognized two market strategies from data obtained in Hungary, which may constitute a basis for extending the scope of studies in the future.

5. Conclusions

Our data suggest the existence of two different strategies for designer drug production and trafficking in Hungary and possibly other countries. The systematic monitoring of, and adaptations to local legislation allowed large sales in relatively short periods for synthetic cannabinoids. Those who marketed cathinones appeared unable or unwilling to follow local regulations – at least in a country as small as

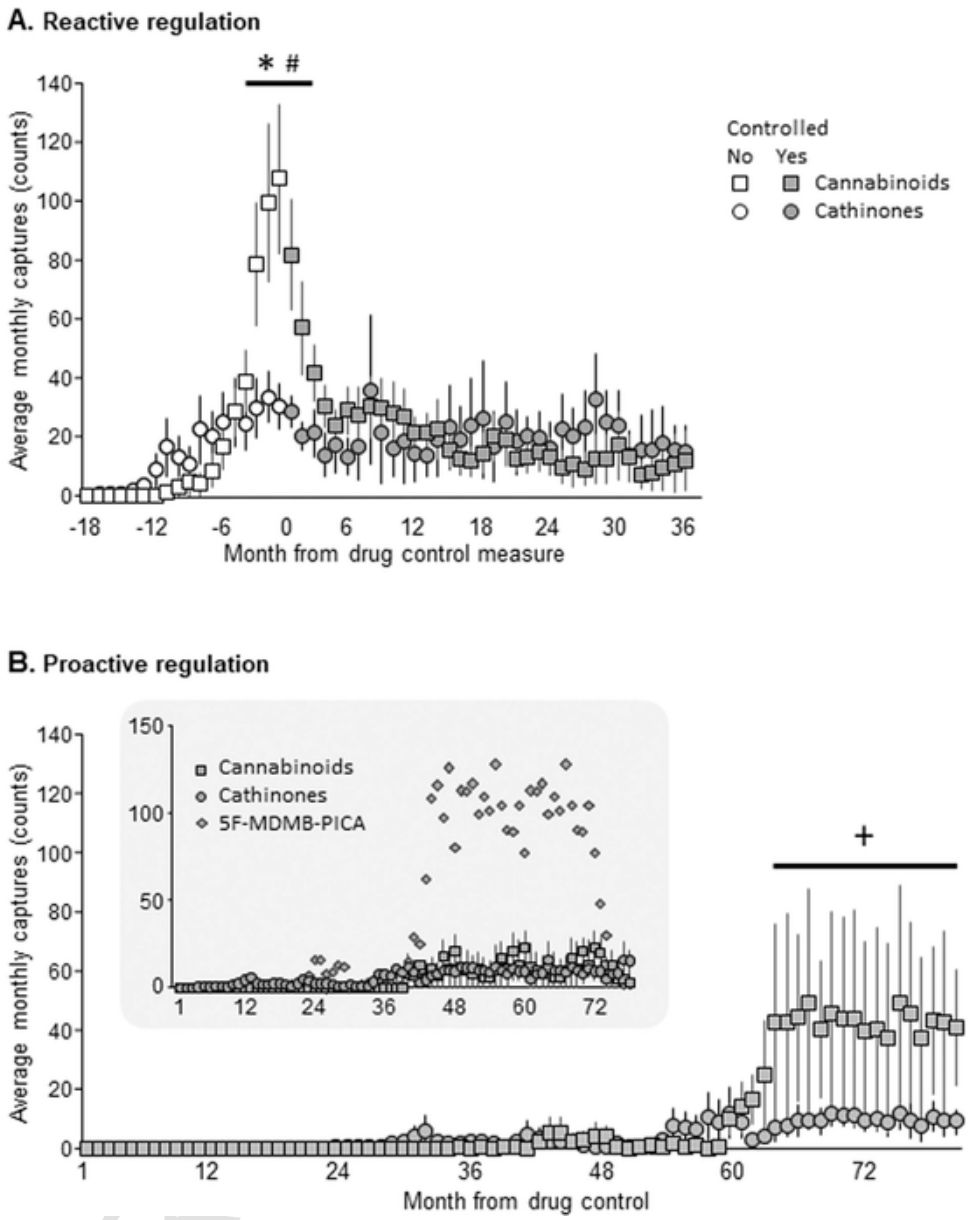

Fig. 6. *The timing of regulations and drug trafficking.* (**A**) Synthetic cannabinoids (15 substances) and cathinones (5 substances) regulated in response to their emergence on the market (reactive regulation). (**B**) Synthetic cannabinoids (3 substances) and cathinones (6 substances) regulated before their emergence on the market (preemptive regulation). **Insert**: the trafficking of 5 F-MDMB-PICA as compared with other synthetic cannabinoids and cathinones that were regulated preemptively. Post hoc comparisons: * , significantly different from all other time points of synthetic cannabinoid trafficking. Note that no such period occurred with cathinones; # significant cannabinoid-cathinone difference. In both cases, $p < 0.05$ (at least) after Bonferroni correction; + , marginal cannabinoid-cathinone difference (significance lost after Bonferroni correction).

Hungary. They marketed these compounds in small but stable amounts, likely due to the risks they involved. Although the number of sales per unit time was small, low-profile trafficking was surprisingly persistent, which may have ensured a reasonable profitability.

Several measures were implemented in the EU to address the problem of designer drugs [38]. Evaluating the market strategies of producers and traders may increase the successfulness of such efforts.

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CRediT authorship contribution statement

József Haller : Conceptualization, Writing – review & editing, Supervision. **Éva Rompos :** Methodology, Software, Validation, Investigation, Resources. **Írisz Szabó :** Formal analysis, Data curation, Writing – original draft, Visualization. **Viktória Humli :** Writing – original draft, Visualization. **László Christián :** Conceptualization, Resources.

Declaration of Competing Interest

The authors declare no conflict of interest.

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