International Journal of Drug Policy 87 (2021) 103013

Contents lists available at ScienceDirect

International Journal of Drug Policy

journal homepage: www.elsevier.com/locate/drugpo

Research Paper

Fentanyl analogs on the Swedish webforum flashback: Interest and impact of scheduling

Kim Moeller [a,*], Bengt Svensson [b], Rasmus Munksgaard [c]

[a] Department of Criminology, Malmö University, Sweden
[b] Department of Social Work, Malmö University, Sweden
[c] École de criminologie, Université de Montréal, Canada

ARTICLE INFO

Keywords:
Fentanyl
NPS
Synthetic opioids
Sweden

ABSTRACT

Background: Sweden regulates new psychoactive substances, including fentanyl analogs, individually. This reactive scheduling procedure enabled the existence of a recreational market for unscheduled fentanyl analogs sold from surface webshops. We measure the interest in 24 named fentanyl analogs and the impact of scheduling.
Methods: We scraped posts in threads on named fentanyl analogs from the Swedish internet forum Flashback.org, 2012–2019. The sample consists of 24 threads with a total of 8761 posts. We construct five measures of interest based on duration of threads, number of posts, and number of distinct posters, and fit a non-seasonal ARMA model to test if there was a change in mean activity after scheduling.
Results: Across the five measures, there was most interest in acryl fentanyl, butyr fentanyl, and acetyl fentanyl. The number of daily posts was significantly reduced in nine out of 13 threads after scheduling.
Conclusion: The scheduling of fentanyl analogs impacted interest on Flashback.org. The biggest effect sizes were from the narcotics scheduling of 2-Me-MAF, acryl, and acetyl fentanyl, while furanyl fentanyl saw the biggest reduction after health scheduling. The reductions were bigger for narcotics scheduling compared to health scheduling.

Introduction

Clandestinely produced non-pharmaceutical fentanyl contaminates the street heroin supply in North American, and has been a key driver in the overdose epidemic (Mars, Rosenblum & Ciccarone, 2019). These synthetic opioid analogs are severeal times more potent than heroin per mg (Ciccarone, Ondocsin & Mars, 2017; Suzuki & El-Haddad, 2017) and are increasingly becoming a problem in Europe as well (Guerrieri, Rapp, Roman, Thelander & Kronstrand, 2017; Mounteney, Giraudon, Denissov & Griffiths, 2015), including Sweden, the location for this study. While Sweden is known for its strict drug control policies (Moeller, 2019) it regulates new psychoactive substances (NPS) individually, as opposed to the collective scheduling of compounds structurally derived from fentanyl, as in the US and China (Armenian, Vo, Barr-Walker & Lynch, 2018; Reuter & Pardo, 2017). This procedure implies that new analogs are introduced at a faster rate than authorities can ban them (Mars et al., 2019; Suzuki & El-Haddad, 2017).

The Public Health Agency makes legal recommendations on individual substances, and the Government decides to schedule them. Substances scheduled under the law Prohibition of Certain Goods Dangerous to Health, are illegal to sell and possess (Svensk författningssamling, 2011, p. 111), and substances scheduled under the Narcotic Drug Control Ordinance are illegal to sell, possess, and use (Svensk författningssamling, 1992, p. 860). The status of individual analogs under review by The Public Health Agency are posted online (Polisen, 2018). This legal framework enabled the existence of a recreational market for fentanyl analogs. Surface webshops made a business by importing "research chemicals" in bulk from China, repackaging and distributing domestically, primarily as nasal sprays but also pills (Guerrieri et al., 2017; Helander, Bäckberg, Signell & Beck, 2017).

In this study, we use data from the Swedish internet forum Flashback.org to provide a user perspective on how the legal process of reactive scheduling shaped the Swedish fentanyl market. We measure user interest in 24 fentanyl analogs by counting posts on Flashback.org from 2012 to 2019. We rank the analogs according to the intensity of interest and illustrate the "samsaric cycle of birth, death and rebirth"

ORCID: 0000-0002-4417-1253
* Corresponding author.
E-mail address: Kim.moeller@mau.se (K. Moeller).

https://doi.org/10.1016/j.drugpo.2020.103013
Received 15 June 2020; Received in revised form 11 October 2020; Accepted 13 October 2020
Available online 9 November 2020
0955-3959/© 2020 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

(Reuter & Pardo, 2017, p. 26), that is, introduction, scheduling, and re-introduction of new analogs.

Only limited research has examined user perceptions of fentanyl. Greenwald (2008) found that, in a controlled setting, pharmaceutical fentanyl ranked highest among various opioids as measured in a willingness to pay analysis of drug preference. Another early study, found that fentanyl was a highly desired, but relatively expensive drug among street opioid users (Firestone, Goldman & Fischer, 2009). The current problems do not stem from intentional misuse of pharmaceutical fentanyl but from non-pharmaceutical fentanyls in heroin (Ciccarone, Ondocsin & Mars, 2017; Suzuki & El-Haddad, 2017). Mars et al. (2019) noted that this disguised sale of fentanyl implies that we do not know much about whether users like it or not.

Users with a high heroin tolerance and physical dependence, prize more potent heroin containing fentanyl over the purest heroin (Mazhnaya et al. 2020). Mars, Ondocsin and Ciccarone (2018, p. 167) termed this fentanyl appreciation a “quest for potency”. The desirable qualities of fentanyl are the intensity of the rush (McLean, Monnat, Rigg, Sterner & Verdery, 2019), ability to relieve withdrawal symptoms and pain (Kilwein, Hunt & Looby, 2018; Mars et al., 2019), and a long “nod” characterized by relaxation and sedation (Suzuki & El-Haddad, 2017). The undesirable effects follow from the strong μ-opioid receptor agonism, which can cause overdose (Helander et al., 2017; Kilwein et al., 2018).

Suzuki and El-Haddad (2017) collected toxicological studies that estimate the potency ratio of fentanyl analogs to morphine ($n = 8$) and pharmaceutical fentanyl ($n = 12$). In descending order, the highest ratios compared to morphine were for carfentanil, beta-hydroxy-3-methyl fentanyl, sufentanil, 3-methyl-fentanyl, acetyl fentanyl, 4-fluoro fentanyl, butyr fentanyl, and acetyl-alpha-methyl fentanyl. A Swedish study counted confirmed fatal intoxications attributable to specific analogs in 2015–2016, and found that 43 deaths were from acryl fentanyl, 34 from acetyl fentanyl, 13 from 4F-iBF, 10 from furanyl fentanyl and 5 from tetrahydro-furanyl fentanyl (Guerrieri et al., 2017).

Aside from toxicological studies, interviews and surveys with people who inject drugs, user perceptions of new psychoactive substances have been examined using data from internet forums. The increase in the online drug trade since 2012 has spurred interest in the methodological aspects of using this data (Enghoff & Aldridge, 2019). Data is easy to obtain and constitutes observational material from hidden populations discussing sensitive topics that would otherwise be difficult to research (Seale et al., 2010). Materials like forum posts are archived, suitable for analysing interest in and perceptions of substances over time (Kamphausen & Werse, 2019).

Quantitative studies have counted the number of posts and contents of threads to measure the interest in various substances and the impact of scheduling. Pineau and colleagues (2016) found 13 webforums for doping products and measured correlations between indicators of "popularity": the number of topic views and responses, number of topics containing a specific word, the number of distinct authors in each topic, and the duration of threads. For twelve of the forums these indicators all correlated positively, with a Pearson coefficient higher than 0.641. They concluded that all their indicators were suitable for assessing popularity and temporal trends. Their rankings of substances and suppliers applied the percentage of first posts in threads that mention specific brands and products.

Ledberg (2015) examined eight threads on various NPS on Flashback.org, to see if levels of interest changed with scheduling. The threads for each substance had between 1831 and 1173 posts. Using posts per day as a time-dependent measure of interest, he found that the number decreased “dramatically” for seven substances after scheduling. The mean daily number of posts 180 days before scheduling was between 2.8 and 20.8, which fell to between 0.3 and 3.9, 180 days after. Rhumorbarbe and colleagues (2019) similarly counted forum posts on NPS and used them to describe presence, popularity, and pricing of substances over time. They argued that authorities and researchers should utilize online discussions for monitoring NPS.

Contribution

The Swedish piecemeal policy for regulating NPS enabled a recreational fentanyl market with commercially traded nasal sprays and pills, advertised with the concentration of the solution of a named analog. The Flashback.org posts that we count are from drug market participants that actively seek out information and discuss fentanyl analogs. Our analyses therefore speak to questions of user perceptions and their responsiveness to changes in legal regulation. Supply side interventions in drug markets are generally under-researched and our study contributes by utilizing online data to measure user interest in named fentanyl analogs and the impact of scheduling.

Data and methods

We use a longitudinal dataset consisting of posts from the webforum Flashback.org. Flashback is a public online discussion forum, with 1,277,031 registered members (16.1.2020) and two million unique weekly visitors out of a Swedish population of around 10 million. Only members can post, and membership is anonymous and free. Rules forbid selling and buying, mentioning locations and identifiable individuals. Moderators monitor the forum, remove irrelevant posts and point out if a post belongs to another thread. During the study, we did not encounter spam messages or posts that were completely off topic.

Data collection

Using the internal search engine, we searched the subforum "Droger/Opiater och andre opioider" [Drug/opiates and other opioids] for the term "fenta" (11.11.2019), yielding a corpus of 66 threads. A parser was developed using the R package Rvest to browse all pages of the threads and download the relevant contents embedded in the source code (Bradley & James, 2019). For each thread, we downloaded the title of the thread and contents of each post along with the date and the pseudonym of the posters.

From the corpus of 66 threads, we selected threads focused on individual analogs for our analysis. These were identified by having the name of a specific analog in the title, and reading of the first five post to confirm that this was the topic. 24 threads with 8761 posts met this criterion. We verified that each thread downloaded completely by comparing with the Flashback website that lists number of replies for each thread.

The first post is on September 13 2012, and the last is July 26 2019, corresponding to 2507 days with an average of 3.49 posts per day. Table 1 below lists the substances by the common name, short name used in the remainder of the article, and scheduling dates (Polisen, 2018).

Data analyses

To assess the interest in individual analogs, we constructed five measures for each thread: duration from first post to last post, total number of posts, and number of distinct posters. Since there is substantial variation, we also standardize the measures by dividing the observed number of posts with the duration of the thread in days, for a measure of post intensity: posts per day. Lastly, we standardize the number of unique posters in each thread by diving this number with the number of posts in the thread. Next, we assess to what extent these measures assess the same interest by conducting a Pearson correlation and a Spearman’s rank correlation. In the Pearson correlation the distance between values matter while the Spearman’s rank correlation is the relative rank. We rank the substances based on the measure that most strongly correlates with the other measures.

To test if scheduling affected post intensity, we present an

Table 1
Fentanyl analogs discussed in the sample.

Common name	Short name	First mention on Flashback.org	Health scheduling	Narcotics scheduling
Butyr fentanyl	Butyr	13.9.12		18.8.15
Acetyl fentanyl	Acetyl	23.8.13		18.8.15
Benzene-sulfonamide (W-15)	W-15	29.11.13		
U-47700	U-47700	20.11.14		
Para-fluoro-isobutyryl-benzyl	Fluoro-iBF	6.1.15		
Para-fluoro-furanyl fentanyl	Fluoro-furanyl	30.4.15		
4-Methoxy-butyr fentanyl	4-MeO-BF	30.4.15	26.1.16	
Furanyl fentanyl	Furanyl	30.4.15	26.1.16	25.1.17
Acryl fentanyl	Acryl	9.1.16		16.8.16
4-Chloro-isobutyr fentanyl	4Cl-iBF	13.4.16	25.1.17	
4-Fluoro-isobutyryl fentanyl	4F-iBF	20.6.16	25.1.17	12.12.17
Cyclopentyl fentanyl	Cyclopentyl	22.8.16	25.1.17	
Tetrahydro-furanyl fentanyl	Tetrahydro	30.8.16	25.1.17	12.12.17
Methane-U-47700	M-U-47700	3.10.16		
Benzodioxole fentanyl	Benzodioxole	7.11.16	28.7.17	
Metoxyacetyl fentanyl	Metoxyacetyl	12.11.16	25.1.17	12.12.17
U-49000	U-49000	25.11.16		
Tetramethyl-cyclopropane fentanyl	Tetramethyl	4.3.17		
N-Fu fentanyl	N-Fu	10.3.17		
4-Methyl-methoxyacetyl fentanyl	4-Me-MAF	13.6.17	18.10.17	12.12.17
2-Methyl-methoxyacetyl fentanyl	2-Me-MAF	12.9.17	18.10.17	12.12.17
3-Methyl fentanyl	3-Methyl	11.12.17		31.10.89
Piperidylthiambutene	Piperidyl	1.11.18		
Parafluor fentanyl	Fluor	14.3.19		1990

Note: Common names are from the Cayman Chemicals website, e.g. https://www.caymanchem.com/product/22750/para-fluoro-furanyl-fentanyl-(hydrochloride) and Wikipedia https://en.wikipedia.org/wiki/List_of_fentanyl_analogues.

interrupted time series of the mean post count per day with a slope change at the day(s) of the schedule change(s). We extracted data from 180 days preceding and 180 days following the scheduling dates. Not all of the analogs had observations on 180 days on either side of the health and narcotics scheduling. For these analogs, we set the duration to 90 days. There are seven analogs scheduled as narcotic with data for 180 days before and after and two with 90 days of data before and after. Three analogs scheduled as dangerous to health have data 180 days before and after, and two have 90 days of data on either side. For two analogs, furanyl and 4F-iBF, there is non-overlapping data from before and after health scheduling, and before and after narcotics scheduling. We excluded the analogs that are not classified ($n = 9$) and two analogs where the time between health and narcotic scheduling was too short to create a non-overlapping time series.

For each of the 13 scheduled analogs with sufficient before-and-after data, we fit a non-seasonal ARMA (zero mean autoregressive moving average) model that captures potential autocorrelation in the error term. This model fits a linear relationship between daily number of posts and the intervention with the following equation:

$$y_t = \mu + \beta I_t + \varepsilon_t,$$

Where y_t is the number of posts on day t, μ is a constant for the mean posts per day value. β measures the effect of scheduling as modelled by the step function I_t. I is a dummy variable that is coded as "0″ before the scheduling date when $t \leq 180$, and "1″ after the scheduling date when $t > 180$. ε_t is the error term modelled as an ARMA time series. For the analogs that only have 90 days of data before and after scheduling, we set I as "0″ when $t \leq 90$ and "1″ when $t > 90$. The error term ε is modelled as an ARMA time series (p, q) consisting of an autoregressive AR (p) component, a moving average MA (q) component and white noise. AR(p)captures autocorrelation between consecutive observations and MA(q)accounts for lagged forecast errors. We examined all models with $p < 5$ and $q < 5$ and selected the best fit based on lowest BIC-value. Lastly, we conduct t-tests to assess the significance of the estimated β coefficients, the effect of scheduling, with the null hypothesis that the coefficient is equal to 0. To check the robustness of our results, we also ran the model with a log-transformed and a square rooted dependent variable. If there are many days with no posts and few days with many posts, the distribution of the dependent variable may not be normal as assumed in the model.

Results

Fig. 1 below illustrates how post intensity varies over time and suggests that scheduling affects interest in individual analogs and shapes the market as whole. Visual inspection reveals that there are long periods of inactivity in some of the threads and an overall pattern where the frequency of posts tapers off after scheduling. In a few instances, discussions appear fueled by the news of scheduling as in the case of 3-Methyl where there is no prior discussion, but then a short (71.6 days) and intensive discussion with only 13.3 h between posts on average. Fig. 1 illustrates a pattern where the scheduling of one analog is followed by discussions moving to a new analog. From 2014 to late 2017, several non-scheduled analogs were discussed at the same time on Flashback.

Interest in individual substances

Some analogs were discussed over long periods, while others were discussed only briefly. On average the 24 threads last 519 days (SD = 452) but there is substantial variation, where the shortest thread on piperidyl, started and ended in only 17 days, while the longest thread on butyr lasted 1672 days, more than four years. The average number of posts per thread was 365 (SD = 433), with a minimum of six and a maximum of 1803 for acryl, almost twice as many as the second-most number of posts. The median post count of 141 reflects a skew where only three threads (acryl, acetyl, butyr) have more than one SD over the mean number of posts. Acryl also has the most intense discussions with only 13.3 h between posts, while acetyl has 14.8 h between posts over 558.3 days. Butyr had the third highest number of posts, but they are distributed over a longer period, with 37.2 h between posts. Tetrahydro and cyclopentyl are also intensely discussed, with 10.4 and 14.5 h between posts for periods of 527 and 278 days, respectively. A handful of analogs spawned very little interest with 300–700 h between posts. Para-furanyl only had six posts in total over 587.8 days. The number of unique posters in each thread ranged from 261 for acryl to three threads with less than 10. Each unique poster, posted between one and seven posts in each thread with a mean of 3.6.

In a Pearson correlation, the total number of posts was strongly positively correlated with number of unique posters ($r = 0.975$, $p < .001$), and fairly strongly correlated with posts per unique poster ($r = 0.84$, $p < .001$). Duration was only moderately positively correlated with number of posts ($r = 0.452$, $p = .027$), and unique posters ($r = 0.494$, $p = .014$). Posts per day was positively but only moderately strongly correlated with number of posts ($r = 0.499$, $p = .013$), number of unique posters ($r = 0.472$, $p = .02$), and posts per unique posters ($r = 0.636$, $p = .001$). Number of unique posters was positively and quite strongly correlated with posts per unique poster ($r = 0.812$, $p < .001$). This indicates that the total number of posts, number of unique posters and

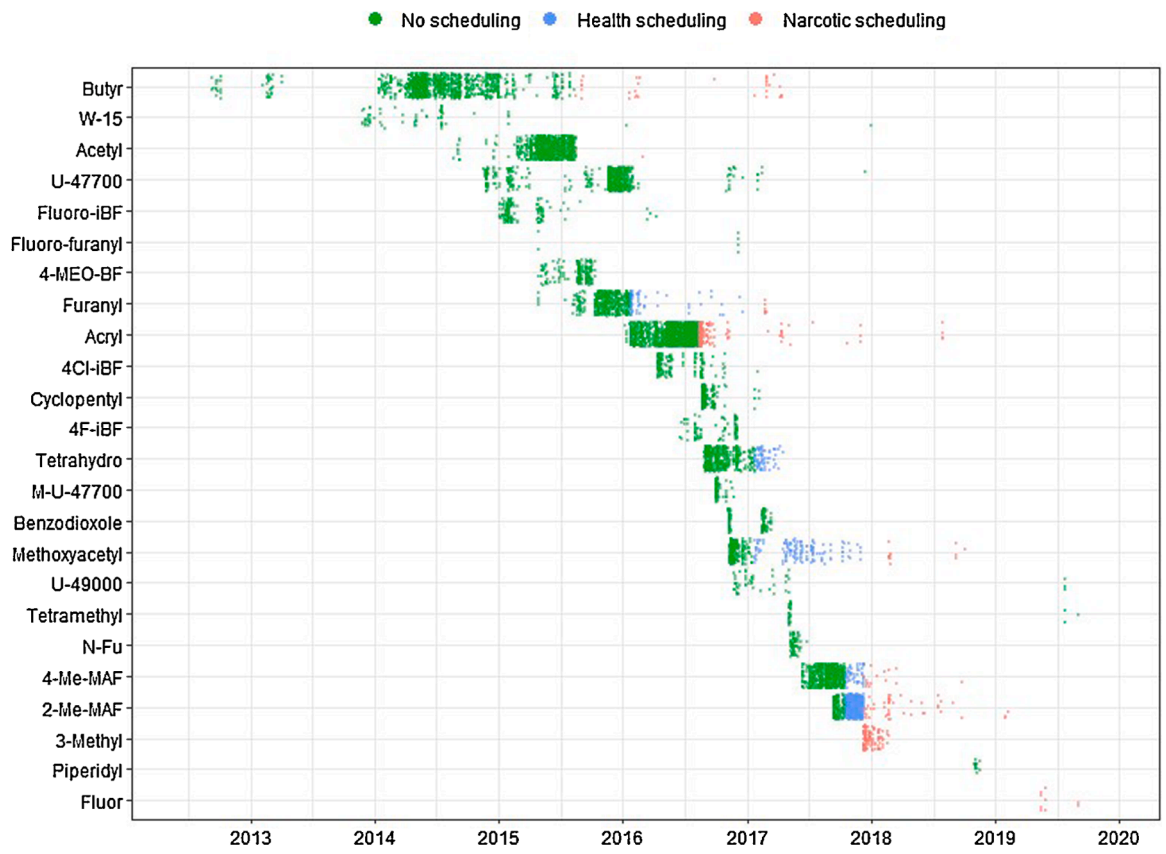

Fig. 1. Posts as a function of time.

posts per unique poster measure the same interest.

Similarly, in a Spearman's correlation, number of posts is strongly and positively correlated with number of unique posters ($rho = 0.977$, $p < .001$), and posts per unique poster ($rho = 0.971$, $p < .001$). Duration is only weakly correlated with the other measures, while posts per day is moderately and positively correlated with number of posts ($rho = 0.617$, $p = .001$), and posts per unique poster ($rho = 0.674$, $p < .001$). Number of unique posters is strongly positively correlated with posts per unique poster ($rho = 0.926$, $p < .001$).

Table 2 below ranks the substances organised by ascending number of total posts. We note that the top three analogs score high on all five measures. Nine out of ten substances with the most interest were scheduled as narcotics. With a few exceptions, the substances scheduled as dangerous to health are in the middle of the table, while the

Table 2
Substances ranked on total number of posts.

Analog	Scheduling status	Posts	Duration, days	Posts per day	SD	Unique posters	Posts per unique poster	SD
Acryl	N	1803	932	1.93	5.03	261	6.9	12.46
Butyr	N	1080	1672	.65	2.04	214	5.0	12.12
Acetyl	N	908	558	1.63	3.90	173	5.2	9.68
2-Me-MAF	N	735	514	1.43	3.95	98	7.5	13.63
U-47700		734	1120	.66	0.28	140	5.2	8.30
4-Me-MAF	N	656	471	1.39	3.13	110	6.0	11.45
Furanyl	N	561	668	.84	2.33	128	4.4	6.67
Tetrahydro	N	527	229	2.30	3.24	109	4.8	7.71
Metoxyacetyl	N	401	692	.58	2.10	100	4.0	5.31
Cyclopentyl	H	278	168	1.66	6.49	67	4.1	4.54
4-MeO-BF	H	174	165	1.05	2.18	52	3.3	3.35
4Cl-iBF	H	149	295	.51	1.48	50	3.0	3.27
Fluoro-iBF		132	459	.29	1.18	37	3.6	5.50
3-Methyl	N	129	72	1.80	3.54	34	3.8	4.34
Benzodioxole	H	105	128	.82	2.53	39	2.7	3.68
4F-iBF	N	88	166	.53	2.18	33	2.7	2.57
M-U-47700		71	54	1.33	3.77	29	2.4	2.34
N-Fu		65	49	1.33	2.12	26	2.5	2.06
W-15		63	1491	.04	0.36	27	2.3	2.18
U-49000		46	973	.05	0.28	31	1.5	0.81
Tetramethyl		28	851	.03	0.41	13	2.2	1.63
Piperidyl		13	17	.76	1.36	9	1.4	0.53
Fluor	N	9	112	.08	0.13	8	1.1	0.38
Fluoro-furanyl		6	588	.01	.13	5	1.2	.45

Note: N = Scheduled as Narcotic; H = Scheduled as dangerous to health.

substances with the least interest are not scheduled. The exceptions are flour and U-47700. Flour was scheduled in 1990 and only has nine posts , and U-47700 is the substance with the fifth most interest but was never scheduled.

Effect of scheduling

As shown in Table 1, nine analogs from the sample ended up scheduled as narcotics, six as dangerous to health. The time from introduction to final narcotic scheduling was 469 days on average (SD = 314), with a minimum of 182 and maximum 1069. 3-Methyl and fluoro were scheduled as narcotics before they were introduced on Flashback. The time from introduction to health scheduling was shorter at 225 days on average (SD = 150). For the six analogs that were first scheduled as dangerous to health and subsequently as narcotics, the time between scheduling was 195 days (SD = 141), with a minimum of 55 days and a maximum of 365 days. Table 3 below displays the results of the interrupted time series regression given the ARMA models. The table is divided into the analogs that were scheduled as narcotics and dangerous to health. Each section is further divided into the analogs where data was available for 180 days around scheduling and 90 days.

As evidenced by the negative β regression coefficients, the mean activity level dropped for all analogs except for cyclopentyl. The intervention analysis tests if the change in post intensity is significantly different from zero. The biggest decreases in post intensity were generally from narcotics scheduling and especially interest in 2-Me-MAF, acryl, and acetyl, declined markedly.Furanyl saw the biggest reduction after health scheduling. The reductions were smaller for health scheduling. Note that the data for furanyl and 4F-iBF enabled analysis of the impact of first health- and subsequently narcotics scheduling. For furanyl, the number of daily posts decreases by almost 90 percent after health scheduling, followed by a very small further decrease after narcotics scheduling. For 4F-iBF there are suddenly no posts at all for 180 days after health scheduling, but then a few posts leading up to narcotics scheduling. The analogs where the reduction in post intensity was not statistically significant were characterized by low mean levels of daily posts prior to scheduling. All of the threads that had more than an average of one post per day leading up to either form of scheduling saw a significant decrease in post intensity after scheduling.

Table 3
Mean number of posts per day before and after health and narcotics scheduling, parameter estimates, significance of the difference, and error terms.

Substance	Post/day		Model parameters				
	Before	After	μ	β	SE (β)	t-test P value	ARMA error p, q
	Narcotics scheduling 180 days						
4-Me-MAF	3.56	.08	2.97	−2.49	1.20	.038	1, 2
Acetyl	4.92	.01	4.90	−4.88	.54	< 0.001	0, 1
Acryl	8.41	.74	7.47	−6.07	2.20	.006	1, 2
Butyr	.34	.07	.35	−0.27	.14	.049	1, 0
Furanyl	.04	.04	.04	−0.01	.05	.904	2, 0
Metoxy	.30	.04	.30	−0.25	.11	.018	2, 0
	90 days						
2-Me-MAF	7.29	.32	7.34	−6.77	1.28	< 0.001	4, 4
4F-iBF	.52	.04	.30	−0.06	.44	.900	1, 0
	Health scheduling 180 days						
4Cl-iBF	.27	.01	.26	−0.26	.12	.026	1, 0
4F-iBF	.43	0	.40	−0.39	.24	.113	1, 0
Furanyl	2.70	.31	2.70	−2.39	.29	<0.001	0, 0
	90 days						
Cyclo	.03	.06	.03	.02	.05	.623	0, 1
Tetrahydro	1.83	.73	1.83	−1.10	.30	.001	0, 0

Discussion

Online discussions of fentanyl analogs on the Swedish webforum Flashback were investigated using five measures of interest and an interrupted time series analysis of the impact of scheduling.

We first ranked the interest in the different analogs. Similar to Rhumorbarbe et al. (2019) study, we found that the measures were strongly and positively correlated, i.e. total number of posts, number of unique posters and posts per unique poster. We note that nine substances stand out in terms of interests with 98 or more unique posters. The substance with the tenth most posters only had 67, so there is gap in this measure. The two most intensely discussed substances were acryl and acetyl while other such as fluor and fluorio-furanyl attracted very little attention on Flashback. There appears to be an association between interest and Swedish scheduling status as nine of the top ten substances were scheduled as narcotics. With a few exceptions, the substances that were scheduled as dangerous to health are placed in the middle of the table and the substances that garnered the least interest are not scheduled. The direction of this association is not known. Rhumorbarbe and colleagues (2019) suggested that authorities monitor internet forums for emerging NPS and it is plausible that representatives of the Swedish authorities follow Flashback.org when considering the scheduling status of fentanyl analogs.

Another possible explanation is that the interest reflects the potency of the analogs. Research on user perceptions found that some heroin users prefer potency to purity (Mars et al., 2019; Mazhnaya et al., 2020). The threads on acryl and acetyl were among the highest in our ranking of interest and they were also identified in most cases of fatal intoxications in Sweden from 2015 to 2016 (Guerrieri et al., 2017). The three most potent fentanyl analogs identified by Suzuki and El-Haddad (2017) were not discussed on Flashback. However, the second and third highest ranked analogs in our study, acetyl and butyr, had the fifth and seventh highest potency ratios compared to morphine. When taken together, this could suggest a connection between potency and interest, where the most potent analogs attract the most interest. However, as noted by Armenian and colleagues (2018) this is also a question of availability on the Swedish market. Our study does not answer this due to the nature of the data collection where the analogs that were first mentioned early in the period of observation had more time to amass posts and public attention. Butyr, acetyl, and U-47700 ranked high on our measures of interest and were among the first on the recreational market in Sweden. The highest ranked analog, acryl, was first mentioned in 2016. Except for 4-Me-MAF, 2-Me-MAF and 3-Methyl, the analogs that were introduced after 2016 rank low on our measures of interest.

Next, we found a substantial decrease in mean post intensity after the scheduling change for most of the threads. The results of our interrupted time series of data covering late 2012 to late 2019 are consistent with research that has examined interest in new psychoactive substances using online data (Ledberg, 2015; Martin, Cunliffe, Décary-Hétu & Aldridge, 2018; Rhumorbarbe et al., 2019). The biggest effect sizes were from narcotics scheduling for 2-Me-MAF, acryl, and acetyl, while furanyl saw the biggest reduction after health scheduling. Generally, the reductions were smaller for health scheduling. Acryl and acetyl are high ranking on all measures of interest while the situation is different for butyr. Butyr has the longest duration thread of all analogs, but interest in this substance waned before scheduling, as seen in Fig. 1 and table 3. The mean post intensity before scheduling was low, and much lower than both acryl and acetyl. The fentanyl analogs we examined were less widely discussed compared to the NPS in Ledberg's (2015) study of mostly stimulants and hallucinogens. The range of mean daily posts prior to scheduling in his study was 2.8 – 20.8 while our sample ranged from 0.04 – 8.4. The coefficients for the decrease following scheduling were in a similar range between the studies. Ledberg's (2015) he found effect sizes of scheduling between −0.8 and −2.8 (with a square rooted dependent variable) for the seven of eight substances where the drop was statistically significant at $p < .001$. Our effect sizes for results with p

= .001 or less (when modeling the dependent variable as square root of daily posts) were smaller, between −0.45 and −2.2.

The decreases in post intensity reflect the intended consequence of scheduling. By criminalizing individual fentanyl analogs, authorities impose substantial transaction costs on their sale and acquisition. Suppliers have to convince buyers that the new analogs are of a similar quality as the scheduled analogs. Moeller & Svensson, 2020 found that fentanyl users in Sweden were keenly aware of the scheduling process regarding fentanyl analogs. They would discuss the dates posted online and compare the psychoactive properties of newly introduced analogs with the ones that became unavailable. Fig. 1 illustrates the unintended consequence of scheduling. For most of the period under examination, several different fentanyl analogs were discussed on Flashback. Producers and suppliers managed to introduce new and unscheduled analogs in Sweden. Reuter and Pardo (2017) noted that the new fentanyl analogs are a function of what the government has prohibited. Improving technological capabilities in China and India have contributed to an increase in the number of fentanyl analogs. However, it may be increasingly difficult for these clandestine producers to come up with modifications that retain potency and desirable psychoactive properties. This could have the unintended consequence that the new modifications are even more dangerous. This perverse substitution effect of scheduling occurred after the ban of the NPS mephedrone (Nutt, 2011).

There are several limitations to our study. Our five measures of interest are measures of discussion and do not necessarily indicate positive evaluations of the analogs. An unknown share of posts were warnings of adverse health effects, but we counted them as expressions of interest. Acryl is highest ranked analog in our analysis and was very intensely discussed during 2016. This is also the period where a high number of fatalities were ascribed to that specific analog (Guerrieri et al., 2017), which likely fueled the discussion. Conversely, these fatalities could be a consequence of widespread use due to desirable psychoactive properties of this particular analog. Future research should combine quantitative and quality elements and conduct a sentiment analyses on the contents of the posts to assess the proportions of posts that are positive and negative. This would provide a better expression of user perceptions of desirable qualities of the various analogs.

References

Armenian, P., Vo, K. T., Barr-Walker, J., & Lynch, K. L. (2018). Fentanyl, fentanyl analogs and novel synthetic opioids: A comprehensive review. *Neuropharmacology, 134*, 121–132. https://doi.org/10.1016/j.neuropharm.2017.10.016.

Bradley, A., & James, R. J. (2019). Web scraping using R. *Advances in Methods and Practices in Psychological Science, 2*(3), 264–270. https://doi.org/10.1177/2515245919859535.

Ciccarone, D., Ondocsin, J., & Mars, S. G. (2017). Heroin uncertainties: Exploring users' perceptions of fentanyl-adulterated and -substituted 'heroin. *International Journal of Drug Policy, 46*, 146–155. https://doi.org/10.1016/j.drugpo.2017.06.004.

Enghoff, O., & Aldridge, J. (2019). The value of unsolicited online data in drug policy research. *International Journal of Drug Policy, 73*, 210–218. https://doi.org/10.1016/j.drugpo.2019.01.023.

Firestone, M., Goldman, B., & Fischer, B. (2009). Fentanyl use among street drug users in Toronto, Canada: Behavioural dynamics and public health implications. *International Journal of Drug Policy, 20*(1), 90–92. https://doi.org/10.1016/j.drugpo.2008.02.016.

Guerrieri, D., Rapp, E., Roman, M., Thelander, G., & Kronstrand, R. (2017). Acrylfentanyl: Another new psychoactive drug with fatal consequences. *Forensic Science International, 277*, 21–29. https://doi.org/10.1016/j.forsciint.2017.05.010.

Helander, A., Bäckberg, M., Signell, P., & Beck, O. (2017). Intoxications involving acrylfentanyl and other novel designer fentanyls–results from the Swedish STRIDA project. *Clinical Toxicology, 55*(6), 589–599. https://doi.org/10.1080/15563650.2017.1303141.

Kamphausen, G., & Werse, B. (2019). Digital figurations in the online trade of illicit drugs: A qualitative content analysis of darknet forums. *International Journal of Drug Policy, 73*, 281–287. https://doi.org/10.1016/j.drugpo.2019.04.011.

Kilwein, T. M., Hunt, P., & Looby, A. (2018). A descriptive examination of nonmedical fentanyl use in the United States: Characteristics of use, motives, and consequences. *Journal of Drug Issues, 48*(3), 409–420. https://doi.org/10.1177/0022042618765726.

Ledberg, A. (2015). The interest in eight new psychoactive substances before and after scheduling. *Drug and Alcohol Dependence, 152*, 73–78. https://doi.org/10.1016/j.drugalcdep.2015.04.020.

Mars, S. G., Ondocsin, J., & Ciccarone, D. (2018). Sold as heroin: Perceptions and use of an evolving drug in Baltimore, MD. *Journal of Psychoactive Drugs, 50*(2), 167–176. https://doi.org/10.1080/02791072.2017.1394508.

Mars, S. G., Rosenblum, D., & Ciccarone, D. (2019). Illicit fentanyls in the opioid street market: Desired or imposed? *Addiction (Abingdon, England), 114*, 774–780. https://doi.org/10.1111/add.14474.

Martin, J., Cunliffe, J., Décary-Hétu, D., & Aldridge, J. (2018). Effect of restricting the legal supply of prescription opioids on buying through online illicit marketplaces: Interrupted time series analysis. *BMJ (Clinical research ed.), 361*, K2270. https://www.bmj.com/content/361/bmj.k2270.

Mazhnaya, A., O'Rourke, A., White, R. H., Park, J. N., Kilkenny, M. E., & Sherman, S. G., & Allen, S.T. (2020). Fentanyl preference among people who inject drugs in West Virginia. *Substance Use & Misuse, 55*, 1774–1780. https://doi.org/10.1080/10826084.2020.1762653.

McLean, K., Monnat, S. M., Rigg, K., Sterner, G. E., & Verdery, A. (2019). "You never know what you're getting": Opioid users' perceptions of fentanyl in Southwest Pennsylvania. *Substance Use & Misuse, 54*(6), 955–966. https://doi.org/10.1080/10826084.2018.1552303.

Moeller, K. (2019). Sisters are never alike? Drug control intensity in the Nordic countries. *International Journal of Drug Policy, 73*, 141–145. https://doi.org/10.1016/j.drugpo.2019.06.004.

Moeller, K., & Svensson, B. (2020). "Shop until you drop" – Valuing fentanyl analogs on a Swedish internet forum. *Journal of Drug Issues*. early online https://journals.sagepub.com/doi/10.1177/0022042620964129.

Mounteney, J., Giraudon, I., Denissov, G., & Griffiths, P. (2015). Fentanyls: Are we missing the signs? Highly potent and on the rise in Europe. *International Journal of Drug Policy, 26*, 626–631. https://doi.org/10.1016/j.drugpo.2015.04.003.

Nutt, D. (2011). Perverse effects of the precautionary principle: How banning mephedrone has unexpected implications for pharmaceutical discovery. *Therapeutic Advances in Psychopharmacology*, 35–36. https://journals.sagepub.com/doi/full/10.1177/2045125311406958#articleCitationDownloadContainer.

Pineau, T., Schopfer, A., Grossrieder, L., Broséus, J., Esseiva, P., & Rossy, Q. (2016). The study of doping market: How to produce intelligence from Internet forums. *Forensic Science International, 268*, 103–115. https://doi.org/10.1016/j.forsciint.2016.09.017.

Polisen. (2018). *Nationell lägesbild fentanylanaloger*. Nationella operativa avdelningen. Sammanställningen är daterad 2018-06-19.

Reuter, P., & Pardo, B. (2017). Can new psychoactive substances be regulated effectively? An assessment of the British psychoactive substances bill. *Addiction (Abingdon, England), 112*(1), 25–31. https://doi.org/10.1111/add.13439.

Rhumorbarbe, D., Morelato, M., Staehli, L., Roux, C., Jaquet-Chiffelle, D. O., & Rossy, Q. (2019). Monitoring new psychoactive substances: Exploring the contribution of an online discussion forum. *International Journal of Drug Policy, 73*, 273–280. https://doi.org/10.1016/j.drugpo.2019.03.025.

Svensk författningssamling [Swedish Code of Statutes]. (2011). *Lag om förstorande av visa hälsofarliga missbruks substanser [Destruction of Certain Substances of Misuse Dangerous to Health]*. Stockholm: Justitiedepartementet Å. in: Svensk författningssamling [Swedish Code of Statutes] 2011.

Svensk författningssamling [Swedish Code of Statutes]. (1992). *Lag om kontroll av narkotika [Narcotic drug controls act]*. Stockholm: Justitiedepartementet Å. in: Svensk författningssamling [Swedish Code of Statutes] 1992.

Seale, C., Charteris-Black, J., MacFarlane, A., & McPherson, A. (2010). Interviews and internet forums: a comparison of two sources of qualitative data. *Qualitative Health Research, 20*(5), 595–606. https://doi.org/10.1177/1049732309354094.

Suzuki, J., & El-Haddad, S. (2017). A review: Fentanyl and non-pharmaceutical fentanyls. *Drug and Alcohol Dependence, 171*, 107–116. https://doi.org/10.1016/j.drugalcdep.2016.11.033.