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Exploring Illegal Drugs in Singapore — A Data Perspective

The good, the bad and the ugly of health products



Kenneth Leung Aug 15 · 11 min read ★

All things are poisons, for there is nothing without poisonous qualities. It is only the dose which makes a thing poison.” — Paracelsus



Executive Summary (aka TL;DR)

- Most of the illegal health products reported in Singapore are marketed for sexual enhancement and weight loss.
- Majority of the illegal drugs are labelled in Chinese
- The most common dosage form design is that of a green oblong capsule
- The top 5 most common adulterants are Sildenafil, Sibutramine, Tadalafil, Phenolphthalein, and Lignocaine

Background and Motivation

The lucrative nature of peddling counterfeit and adulterated drugs has led to the proliferation of the global trade of illegal health products. This is also driven by an increase in consumer demand for these products, and the low cost in purchasing them. The obvious downside is that the consumption of these health products purchased from dubious sources run the risk of causing serious health problems to the consumers.

These products often contain undeclared ingredients to enhance the effects to entice consumers to take them. These ingredients may be hazardous (especially if taken without medical supervision), over- or under- dosed, banned or have not been assessed for safe use in humans.

In a bid to better understand the illegal health product trade in Singapore, I decided to conduct an analysis of the publicly released list of detected and tested illegal health products reported by the Health Sciences Authority (HSA).

This analysis was sparked by a conversation I had with a fellow Entrepreneur First cohort member (Shrey Chaturvedi), when we were discussing about potential problems

to tackle in the Southeast Asia counterfeit drug market. I decided it was a good opportunity to work on this mini-project related to what I enjoy — the intersection of drugs and data.

Part I — Sourcing for Data

The database for illegal health products reported by the HSA is available for public viewing on this [page](#). Although this list is not exhaustive, it still serves as a reasonable sample of all the illegal health products being traded in Singapore.

This dataset is presented as a data table on the site, and was accessed and retrieved on 15th August 2020.

S/N	Product Thumbnail Image	Product Description	Dosage Form	Dosage Form Color	Dosage Form Shape	Dosage Form Marking	Remarks for Dosage Form Marking	Adulterants
1		Li Long Brand Jin Gang Shen Dan 2800mg Capsule (力龙牌金刚神丹)	Capsule	Green	Oblong	Yes	力龙生物	Sildenafil
2		Jiu Chong Tian Capsule (九重天)	Capsule	Beige ;Red	Oblong	No		Sildenafil
3		Buda Jin Qiang Bu Dao 800 mg Tablet (金枪不倒)		Brown	Irregular	No		Sildenafil
4		Kang Xi Da Di Long Yang Dan 1000mg Capsule (康熙大第龙阳丹)	Capsule	Green	Oblong	Yes	金鳌力 and two crea...	Sildenafil
5		Zhengtao Brand King of Postponing Spray (延时王)	Spray			No		Lignocaine ;Sildenafil
6		Lang Yi Hao 145mg Tablet (极品狼1号)		Blue	Diamond	Yes	DL	Metronidazole ;Sildenafil
7		Longer Vaigra 1500 mg Capsule (长效伟哥)	Capsule	Blue ;White	Oblong	No		Sibutramine ;Sildenafil
8		Hong Sheng Sheng Wu Brand Li Jia Li (exceed vigra and cialis 3500 mg) Capsule (宏圣生物牌力加力)	Capsule	Green	Oblong	No		Sildenafil
								No of Records: 245

Screenshot of HSA Illegal Health Products Database Search Results

The features available are as follows:

Feature	Brief Description
Product Description	Name and description of the health product
Dosage Form	Formulation of the product e.g. Tablet, Capsule etc.
Dosage Form Colour	The colour of the product formulation
Dosage Form Shape	The shape of the product formulation
Dosage Form Marking	The presence of marking/engravings on the product (Yes/No)
Remarks for Dosage Form Marking	Details of the markings/engravings on the product
Adulterants	Culprit undeclared potent medicinal ingredient(s) in the product

Table of dataset features (columns) and respective description

The contents of the database on the site was manually transcribed and saved as an Excel (.xlsx) file with the use of Notepad++ and Microsoft Excel. This was then imported into Jupyter Notebook for further analysis using Python 3.

Having come across street side counterfeit drug peddlers while overseas on holiday, my initial hypothesis is that these counterfeit drugs are mainly lifestyle products. In particular, the ‘best-seller’ is likely sex-enhancement drugs targeted at the adult male population.

Part II — Data Cleaning

There are a total of 245 reported illegal health products documented in the HSA Illegal Health Products database at the time of this writing.

All 54 rows with *null* values in the ‘Dosage Form’ column were associated with tablets as displayed in the respective ‘Product Description’ column. These *null* values were thus filled with ‘Tablet’ as a dosage form entry, thereby creating a new Dosage Form category of ‘Tablet’ not utilized previously. The count of *null* values for each column in the final dataset is shown below:

```
[23]: df_final.isna().sum()
```

```
Out[23]: Product Description      0
         Dosage Form             0
         Dosage Form Color       9
         Dosage Form Shape      20
         Dosage Form Marking     0
         Remarks for Dosage Form Marking  150
         Adulterants             1
         dtype: int64
```

Frequency count of null values for each column

The *null* values for shape and color were mainly due to products packaged as vials and bottles, which are harder to characterize as compared to the usual oral tablets or capsules.

Given that there was plenty of missing data in the ‘Remarks for Dosage Form Marking’ column (i.e. 61.2% NA), the review of product markings was omitted in this analysis.

There were 13 products with dosage form stated as ‘Pill’, which was an uninformative categorization. The product images were reviewed manually to determine its exact dosage form (i.e. tablet or capsule).

Part III — Insights from Exploratory Data Analysis

Now to the main part of this analysis, which is the patterns and findings observed.

(i) Product Description

The product description gives the name of the product, along with some useful (albeit brief) information about its intended use for the consumer. Given that we are dealing with text strings here, it would be a good idea to use a word cloud generator (with Python WordCloud library) to illustrate the text frequency in these descriptions.

After removing uninformative stop words (e.g. 'Brand', 'Capsule', 'Jiao Nang' (which means capsule in Chinese) 'Tablet'), the following word cloud was produced:

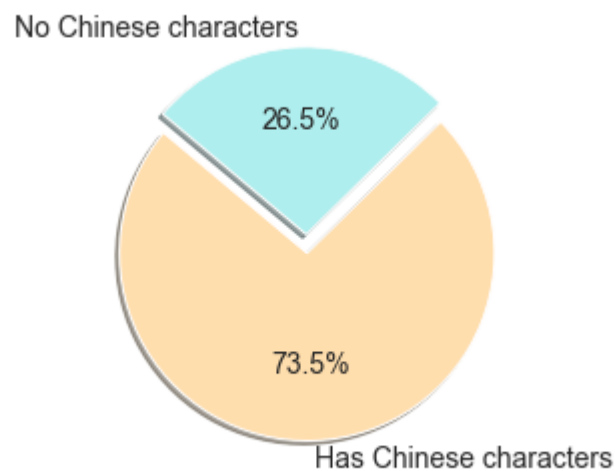




Full word cloud for Product Description

It is clear that most of these words are romanization of Chinese characters (i.e. *Hanyu Pinyin*). This suggests that many products are mainly labelled in Chinese, and interpreting this full word cloud is not the best way to understand the nature of these products.

Given that the word cloud suggests a high occurrence of Chinese characters, it would be interesting to see the proportion of the illegal health products containing Chinese characters in their product description.



Proportion of illegal health products containing Chinese characters in product description

It can be seen that the list of illegal drugs is dominated by products labeled in Chinese (73.5%). This might imply that either the Chinese population is the primary target group for illegal drug dealers, or that these products are sourced primarily from China.

The next step is to generate a Chinese character word cloud. This was done by first using regular expression (*regex*) to extract all Chinese characters from the 'Product Description' column, and using Python's *jieba* library to tokenize these Chinese characters. With certain Chinese stop words removed (e.g. 胶囊), the WordCloud library was used once again to generate a word cloud:

[illegible][illegible]

With this Chinese word cloud, it becomes easier to understand the nature of the illegal health products.

- **Finding 1**

The word America (‘美国’) occurs frequently, implying that dealers tend to market their counterfeit drugs as products of USA, likely to falsely augment its appeal, quality and legitimacy towards consumers. This assertion was confirmed when I looked at these specific products containing ‘美国’, and found these products to be branded with phrases like ‘America Warrior’ and ‘America Viagra’. Another country observed in the word cloud is Germany (‘德国’), meaning that drugs produced in Germany are also associated with strong branding.

- **Finding 2**

The two most common claims made by these health products relate to sexual performance and male genitalia (‘牛鞭’, ‘升阳’, ‘延时’, ‘魔根’), and weight loss (‘减肥’, ‘瘦身’). This is further supported by other frequently occurring nuanced words associated with sexual vitality (‘金聖力’, ‘战神’, ‘动力’, ‘天雄’, ‘神威’).

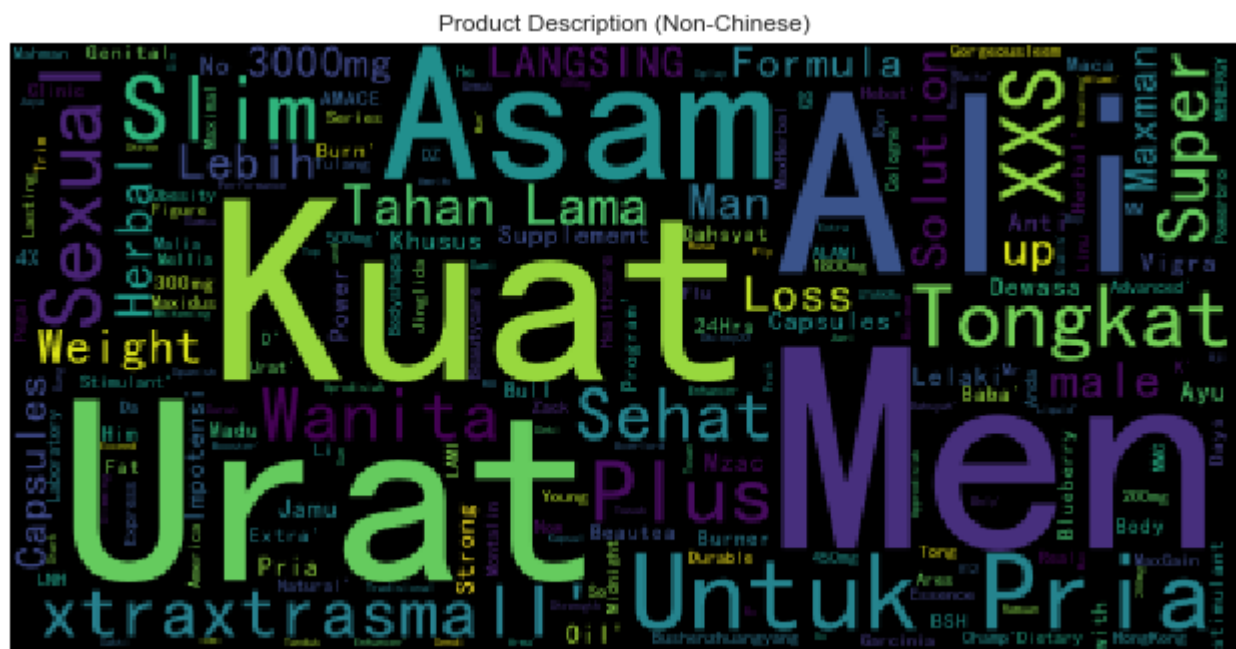
- **Finding 3**

There are several common words associated with dragon (‘龙牌’, ‘天龙’), which is not out of the ordinary since the dragon traditionally symbolizes potent and auspicious powers in Chinese culture.

- **Finding 4**

While drug names are not commonly mentioned in the Chinese descriptions, there is one obvious branded name that appeared frequently, which is Viagra (‘威哥’, ‘伟哥’).

It is also important to analyse the other products that did not contain any Chinese characters, which make up 26.5% of this illegal drugs dataset. After removing English and Malay stop words (e.g. Kapsul, Obat), the generated word cloud is shown below:



Word cloud for products **without** Chinese characters in Product Description

Similar to what was seen earlier for the Chinese-labeled products, these products also appear marketed for weight loss and sexual enhancement for men. This is observed from the English words (e.g. 'Men', 'Sexual', 'Slim', 'Weight'), as well as some of the suggestive

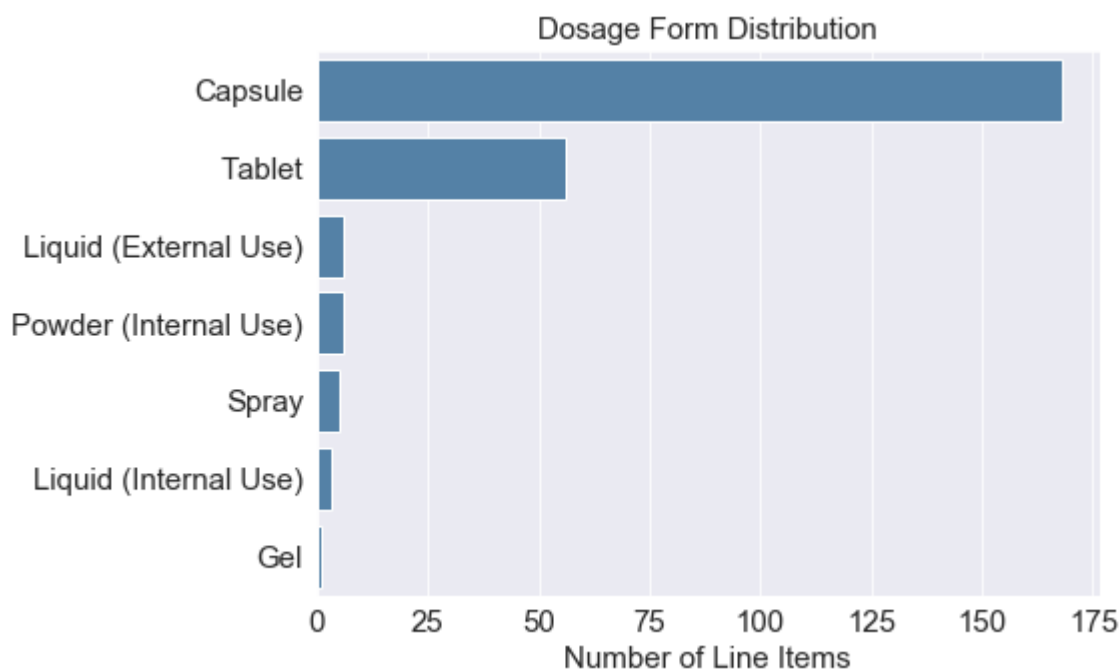
Malay words (e.g. 'Kuat' (strong), 'Untuk Pria' (for men), 'Tongkat Ali' (herb known for its use in managing erectile dysfunction). All these insights support the earlier hypotheses that sexual enhancement drugs are the leading counterfeit products being traded.

- **Finding 5**

Another finding from the word cloud exploration is the presence of the Malay phrase 'Asam Urat', which means *uric acid* in English. High levels of uric acid in the blood is the cause of **gout**, and the frequent occurrence of the Malay phrase of uric acid suggests that there are many counterfeit products marketed for gout management as well.

(ii) Dosage Form

The majority of these illegal health products are in oral solid dosage forms, namely capsules and tablets.



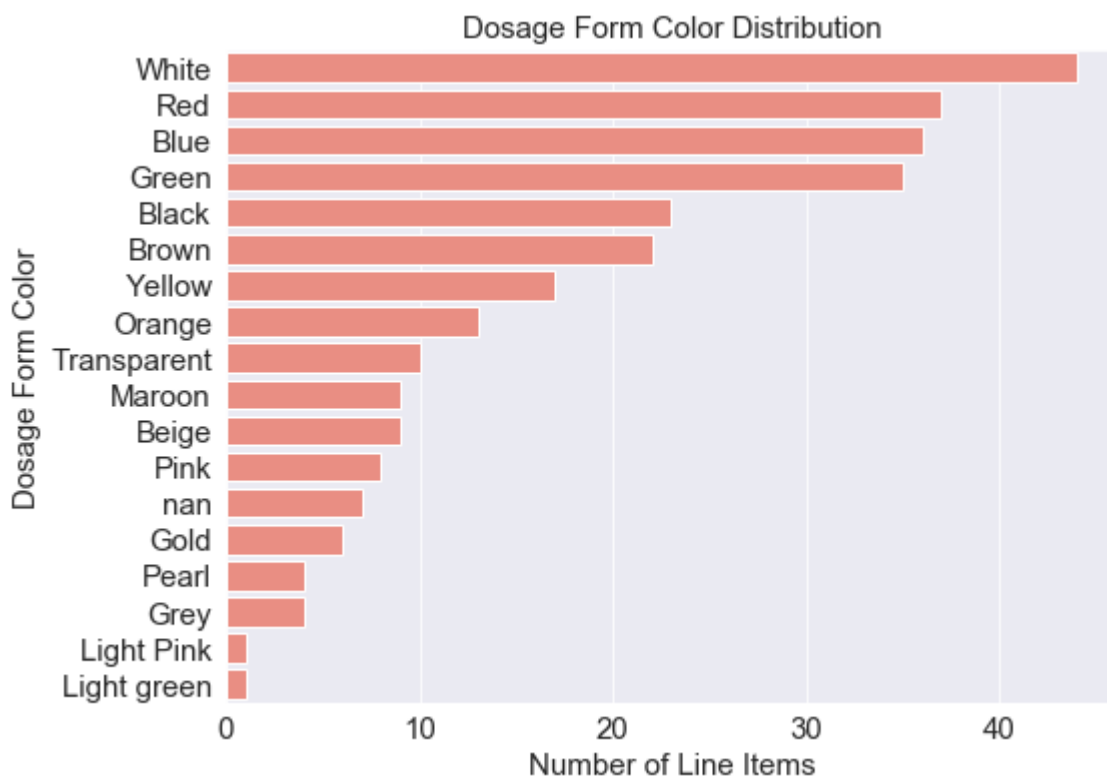
Distribution of the Dosage Forms

This is unsurprising since oral formulations offer many advantages such as:

- Ease of manufacture, packaging and transport
- Good chemical and physical stability
- Relatively low cost of production
- Simple and accurate dosing for consumers

(iii) Dosage Form Color and Shape

Since white is the most commonly occurring color for oral medications in general, it is also not surprising to see that **white** is the predominant color for these illegal health products as well. The next three most common colors happen to be the standard primary colors of red, blue and green.

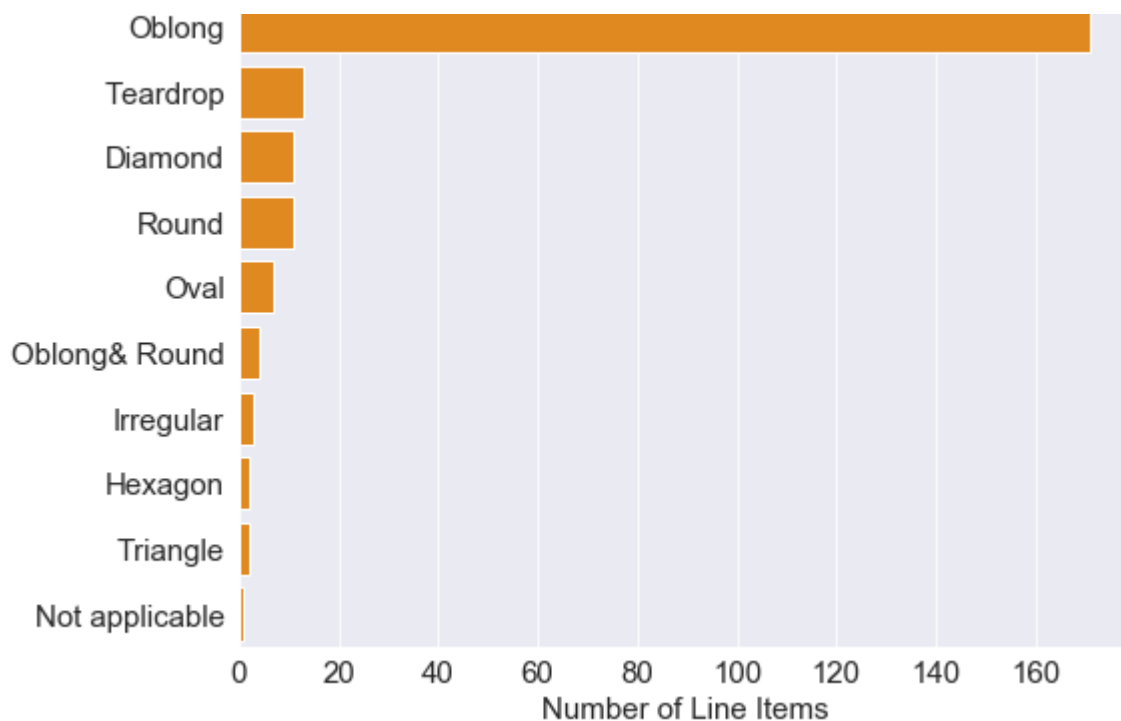


Distribution of the Dosage Form Colors

In terms of the dosage form shape, the predominant shape is **oblong**.

Dosage Form Shape Distribution





Distribution of the Dosage Form Shape

By looking at the above charts separately, you might imagine that the most common design is that of a *white oblong capsule*. However, we should be looking at it from the combined sequence of dosage form, color and shape. With that, it is evident that the most common dosage form design was in fact a *green oblong capsule* instead of a white one.

	Frequency
Capsule, Green, Oblong	29
Capsule, Red, Oblong	17
Capsule, Blue ;White, Oblong	16
Capsule, White, Oblong	12
Tablet, Blue, Diamond	8
Capsule, Pink, Oblong	7
Capsule, Maroon, Oblong	7
Capsule, Gold, Oblong	6
Capsule, Blue, Oblong	6

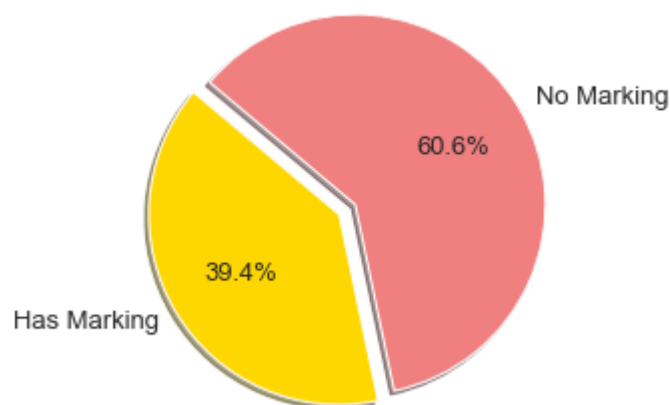
Top 10 most common Dosage Form designs

Here is an example of what a **green oblong capsule** looks like:



(iv) Dosage Form Markings

It can be seen that the majority of these illegal health products (60.6%) do not have any markings on them. This makes it all the more difficult to pinpoint the specific identity of these drugs, as well as to distinguish the counterfeit products from the real ones.



Distribution of products with and without markings/engravings

(v) Adulterants

Adulterants are the undetected and unapproved potent medicinal ingredients in the health product, and these adulterants are the main reasons why these counterfeit products are deemed illegal.

These adulterants can cause **serious adverse health effects** owing to accidental misuse, overuse, or interaction with other medications, underlying health conditions, or other ingredients within the supplement.

The following table show the top 10 most common adulterants that form a part of these illegal products.

	Adulterant	Frequency
0	Sildenafil	144
1	Sibutramine	66
2	Tadalafil	30
3	Phenolphthalein	23
4	Lignocaine	19
5	Dexamethasone	7
6	Piroxicam	6
7	Diclofenac	6
8	Vardenafil	5
9	Chlorpheniramine	4

Top 10 adulterants discovered in the illegal health products

Now would be a good time to bring in some pharmacological knowledge into the fray, by describing the top 5 adulterants seen in the above table.

(1) Sildenafil

What is it? Sildenafil is by far the most common adulterant found in illegal health

products. Sildenafil is the generic name of the active compound found in Viagra (brand name), and is used to treat erectile dysfunction (ED).

Fun Fact: Sildenafil was originally developed for the treatment of pulmonary hypertension and angina pectoris (chest pain due to heart disease). However, during the clinical trials, researchers found the drug to be more effective at inducing erections than treating angina.

Side Effects: While most side effects are generally mild (e.g. flushing, headaches), there is a risk of more severe reactions such as **vision loss, priapism (persistent and painful erection), and severe hypotension**. These risks are certainly amplified when consuming these counterfeit products, whereby the dosages contained within them are poorly regulated.

(2) Sibutramine

What is it? Sibutramine is a compound used for weight loss. This supports the insights gathered earlier that weight loss is a common area which illegal health products tend to target. Sibutramine works by increasing thermogenesis and making the user feel fuller after a meal, and it has mainly been studied in obese patient populations.

Side Effects: It is known to be associated with an **increased risk of cardiovascular events** like **heart attack, stroke and hypertension**.

(3) Tadalafil

What is it? Being in the same drug class as Sildenafil (i.e. Phosphodiesterase-5 Enzyme Inhibitors), Tadalafil is also used to treat ED, and shares many similar features with Sildenafil. Its brand name is Cialis.

(4) Phenolphthalein

What is it? Phenolphthalein is a laxative, and is commonly found in adulterated weight loss products. Multiple dietary supplements containing Phenolphthalein and Sibutramine have been previously recalled by the U.S. Food and Drug Administration (FDA) due to their unapproved inclusion in the supplements.

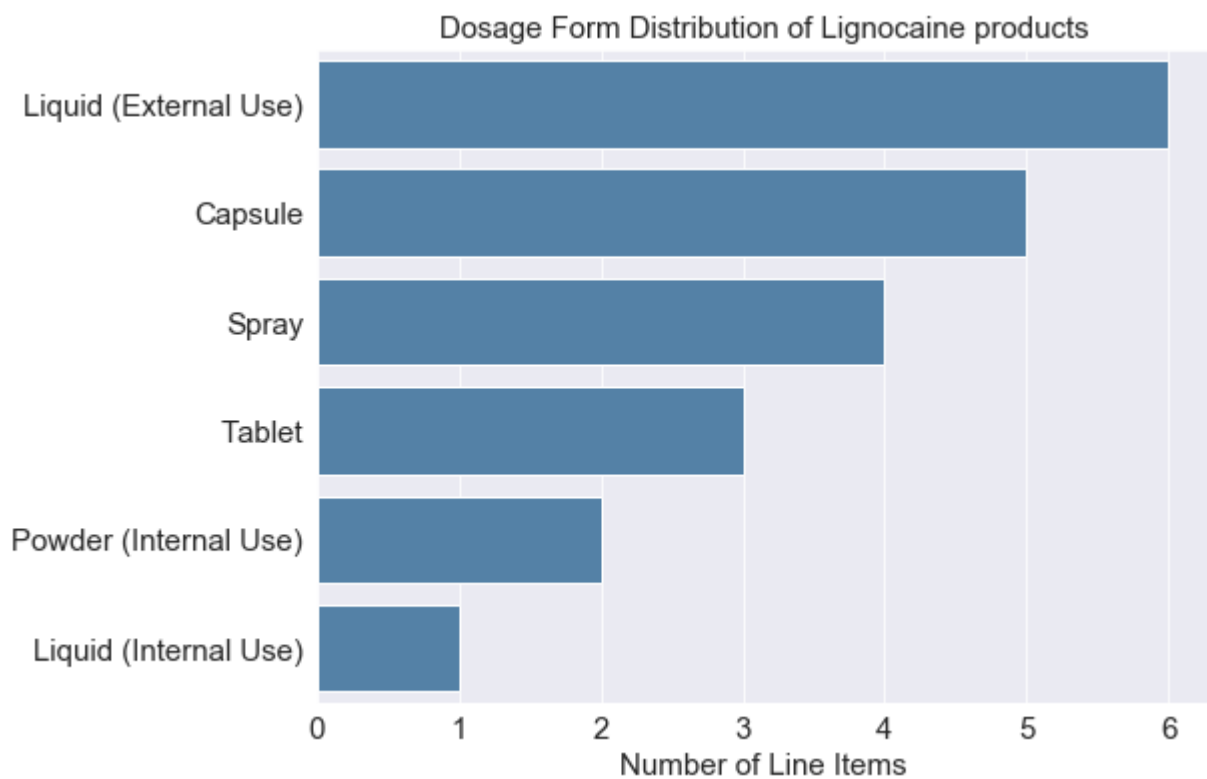
Side Effects: Phenolphthalein exposure has been associated with carcinogenicity (i.e. can cause cancer).

(5) Lignocaine

What is it? Lignocaine is an anesthetic, meaning that it is a medication used to numb tissues in a specific body region when applied topically on the skin or mucous surface. It typically comes in the form of topical products (e.g. spray, gels), and is used to manage premature ejaculation due to its numbing effect.

Side Effects: Topical use has generally mild side effects such as itch/redness, but the potentially poor quality of the illegal product may lead to unexpected hypersensitivity/allergic skin reactions.

From here, I decided to take a closer look at these Lignocaine-containing products, to confirm my hypothesis that all supplements containing Lignocaine are of the topical dosage form.



Dosage Form distribution of Lignocaine-containing products

Although the most common dosage form is indeed something used for topical application (liquid for external use), I was surprised to see that there were quite a number of oral capsule and tablet products containing Lignocaine as well, especially since Lignocaine is not meant for oral consumption. This is certainly something worth looking deeper into.

Next Steps

This analysis offers some insights into the trends and patterns observed in the illegal health product trade in Singapore, which can be of value for authorities like the HSA. For example, by understanding the common marketed claims and main groups of people targeted by illegal dealers, specially curated education campaigns can be conducted to raise awareness so that the public understands how to better protect themselves.

Having access to more data (such as place of purchase, country of manufacture, date of reporting, profiles of peddler/consumer etc.) would also help to make this analysis more insightful and useful in tackling the peddling of such illegal products.

Wrapping things up

In reality, it can be very challenging to distinguish real products from counterfeit ones. So here is some advice from your friendly pharmacist: Always purchase your medications and health products from registered medical institutions, clinics and pharmacies. If you do encounter such illegal products being peddled, you may report it to the HSA Enforcement Branch via phone (6866 3485) or email (hsa_is@hsa.gov.sg)

I look forward to hearing your feedback on the above analysis. If you would like to have a copy of the code, or wish to discuss more about this review, please feel free to drop me a message on [LinkedIn](#)!

Special thanks to [Koo Ping Shung](#) for sharing his feedback on the analysis

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