Trends in illicit drugs based on the analysis of seizures from the Tanzania mainland drugs market

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ABSTRACT

This study aimed at investigating the pattern of confiscated illegal drugs in the Tanzania mainland drug market from 2011 to 2016. The samples used in this study were seized by the police force and other law enforcement agents and were analysed at the Government Chemist Laboratory Authority, GCLA. A total of 90,366 samples weighing 17961.5 Kg were seized and analysed during the six years, an average of 15,061 samples corresponding to 2993.6 Kg per year. The overall results indicated cannabis to be the leading drug in terms of number of cases, number of samples and weights with 51.02%, 60.50% and 56.90%, respectively, but from 2011 to 2015 heroin had the highest percentage of both number of cases and samples by 58.46% and 55.91% of all seizures, respectively followed by cannabis. In terms of weight, heroin accounted for 67.55% and 26.32% in 2011 and 2012, respectively, whereas, the rest of the years’ percentage weights were between 0.50 and 6.00% of the total seizures. The trend indicated a steady decrease in heroin seizures over the six years and an increased cannabis seizure. In 2016 cannabis was 78.28% and 80.89% of the total number of cases and samples, respectively. The results also indicated the decrease of cocaine cases and a significant increase in the amount khat. The year 2016 recorded the highest number of cases and number of samples with a total of 1212 and 48,440, respectively, which resulted from the increase in cannabis seizures by 72.28% and 80.89% of the total number of cases and samples, respectively, as compared to 2015. The second highest years were 2013 and 2014, respectively followed by cannabis. In terms of weight, heroin accounted for 72.28% and 80.89% in 2011 and 2012, respectively, whereas, the rest of the years’ percentage weights were between 0.50 and 6.00% of the total seizures. The trend indicated a steady decrease in heroin seizures over the six years and an increased cannabis seizure. In 2016 cannabis was 78.28% and 80.89% of the total number of cases and samples, respectively. The results also indicated the decrease of cocaine cases and a significant increase in the amount khat. The year 2016 recorded the highest number of cases and number of samples with a total of 1212 and 48,440, respectively, which resulted from the increase in cannabis seizures by 72.28% and 80.89% of the total number of cases and samples, respectively, as compared to 2015. The second and third highest years were 2013 and 2014, respectively. The least was 2011 with 3493 samples. The trend also indicated heroin seizures were highest in 2011 (62.04%), 2014 (75.31%) and 2015 (79.26%) whereas cocaine seizures kept on decreasing gradually from 31.12% in 2011 to 0.05% in 2016. Khat (Catha edulis) had the highest weight in 2014 and 2016 and ranked second after cannabis with 43.63% of the total weight during 2011–2016 period. Benzodiazepines and amphetamine type stimulants (ATS) accounted the least in terms of number of cases and number of samples.

1. Introduction

I illicit drug production, synthesis, transportation and use impose enormous costs on public health and safety [1–4]. The United Nations Office of Drug and Crime (UNODC) recognizes drug abuse as a global problem and works on assisting member states in the fight against illicit drugs [4–7]; it is estimated that some 35.6 million people suffer from drug use disorders globally. According to the world drug report issued by UNODC in 2020, the data of drug users indicated cannabis to be the leading commonly used drug worldwide by an estimated total number of 192 million, followed by opioids with 58 million (opiates 30 million), whereas amphetamines and prescription stimulants accounted 27 million. Ecstasy and cocaine had 21 and 19 million, respectively [8].

According to the report, in the African continent, West Africa was leading, followed by North Africa. East Africa accounted the least in all cases; Tanzania was leading among the East African countries.

Worldwide, a total of 8098 tons of cannabis, cocaine, opium, meth-amphetamine, heroin/morphine, pharmaceutical opioids, amphetamine and ecstasy were seized in 2018. The leading being cannabis, followed by cocaine. The least were ecstasy [9].

As a result of demand and supply, drug trafficking has posed a major global problem with law enforcement worldwide. The traditional law enforcement approaches are often unsuccessful and sometimes exacerbate violence, racial tensions and damage citizens’ perceptions of procedural justice and police legitimacy [8,10].

Analysis of drug seizures could be used as an indicator to reflect the
dimensions of the illicit drug market [11,12]. As with other transnational crimes, the illicit drugs market is well intertwined in terms of processes and activities, leading to a polymorphic criminal network. The drug market can be understood by analysing market share in terms of the distribution of seized drugs over a period of time. This is to a larger extent influenced by the general economic laws such as the growing globalisation and diversification of the market, which equally results in the scaling up of the production.

Elsewhere, a detailed analysis of the illicit drugs has a treasured intelligence value in the documentation of production and trafficking routes, conspiracy links and the establishment of the number of sources of drugs, distribution and distribution networks and understanding the transnational nature of the illicit drugs crimes [13–18].

The government of the United Republic of Tanzania, like other governments in the world, has made various efforts to combat the production, transportation, and drug use. One of the main efforts the government has made is to enact specific legislations and establishment of the Drug Control and Enforcement Authority for the prevention and control of the entire chain involving production, transportation and drug use in the mainland part of the country. In implementing the Act, the Chief Government Chemist has been tasked with conducting investigations into illustrations involving drugs in the country [19].

During the period from 2011 to 2016, the Government Chemist Laboratory Authority has been able to conduct analyses and identify the intrusion and use of heroin, cannabis, khat, cocaine and other drugs of abuse, such as amphetamine type stimulants (ATS), benzodiazepines and the like. This information identifies the extent and type of drugs investigated and submitting the investigative reports to the relevant authorities responsible for provision of justice. (GCLA Report, 2017).

This study aims to critically examine the production, distribution and examining the market share of synthetic illicit drugs (ATS and benzodiazepines) against the market share of semi-synthetic (heroin, cocaine) and the natural drugs, cannabis and khat. On the basis of the information, the study also provides a discussion on the market dynamics of the commonly seized drugs in the Tanzania mainland drug market.

2. Materials and methods

2.1. Materials

The illicit drugs used in this study were mainly seized by the police force and other law enforcement organizations during transportation, from drug markets and from farms for cannabis and khat from different regions in Tanzania mainland. All exhibits collected from drug seizures, with exception of khat, were stored at room temperature. Khat was stored in a freezer.

2.2. Methods

2.2.1. Identification and general analytical scheme

Microscopic characteristics identification was used in the identification of Cannabis sativa L. where a binocular microscope with a magnification factor of 40 was used. The forensic drug testing were carried out using screening and confirmation tests as recommended in literature [20–26]. Detailed sample preparation and instrumentation are as presented in the following sections.

2.2.2. Sample preparation

2.2.2.1. Cannabis. 500 mg of pulverized dry herbal cannabis were extracted using 5 mL chloroform/methanol (1:9). The mixture was vortexed for 10 min followed by 15 min in an ultrasonic bath. The sample was vortexed again after 5, 10, and 15 min then followed by centrifugation. 200 μL of the extract were transferred into a derivatizing vessel and the solvent evaporated under nitrogen to dryness. The sample was decarboxylated for 15 min at 210 °C. The residue was dissolved in 200 μL chloroform/methanol mixture (1:9). The final solution for the analysis was prepared by diluting the decarboxylated solution with methanol by a factor of 100 (100 μL + 900 μL) and then used for analysis.

2.2.2.2. Cocaine. Cocaine was analysed using three different techniques, GC-FID, GC-MS and HPLC. First, the cocaine sample was pulverized and homogenized into a fine powder. For GC-FID, 5 mg of the powder were dissolved in 1 mL methanol, out of which 2 μL of supernatant were injected in the GC-FID system. For GC-MS and HPLC, suitable amounts of samples were extracted using methanol to make a concentration of approximately 1 mg/mL and 0.5 mg/mL solutions, respectively. Then the samples were injected into the corresponding system for analysis.

2.2.2.3. Heroin. A suitable amount of heroin sample was dissolved in methanol to give a final concentration of 1 mg/mL. Then 0.5 mL of the sample solution was drawn and concentrated near to dryness. The derivatization of heroin co-ingredient was achieved by mixing the concentrated sample with 0.5 mL of BSA (N,O-bis(trimethylsilyl)acetamide) in a stoppered vial and heated at 100 °C for 10 min. Then the sample was injected into GC–FID system. The samples analysed by HPLC system were not derivatized.

2.2.2.4. Benzodiazepines. Benzodiazepines mainly consist of pharmaceutical substances formulated as tablets, capsules, oral liquids, or injectables. The sample solutions were prepared in methanol at a concentration of 1 mg/mL, and the samples were analysed either by GC–FID or GC-MS or HPLC.

2.2.2.5. Amphetamines-type stimulants (ATS). An appropriate amount of sample was dissolved in water to make a concentration of 1 mg/mL. 5 mL of the solution were pipetted into a 10 mL glass stopped test tube and a 5% solution of sodium hydroxide was added until the pH of 10 was achieved. 5 mL of chloroform was added to extract the ATS. The solvent layer was transferred through anhydrous sodium sulphate layer using Pasteur pipette into a GC vial and injected into GC–FID and GC-MS Systems. A concentration of 0.5 mg/mL was prepared by dissolving a suitable amount of ATS in the mobile phase and injected into HPLC.

2.2.2.6. Khat. 15 mL of methanol was added to 5 g of plant materials, cut into small pieces and then sonicated for 15 min. The solution was filtered, concentrated to near dryness and 20 mL of 0.2 mol/L sulphuric acid were added. Chloroform was used to remove the natural organic compounds. The aqueous layer was basified with a sodium bicarbonate solution. 20 mL of methylene chloride were added to extract the cathinone and cathine. A stream of nitrogen gas was used to reduce the volume to approximately 1 mL. The sample was analysed by the HPLC system.

2.3. Instrumentations

2.3.1. GC–FID

The analyses were carried out with Varian 3800 GC system equipped with an FID detector. The columns used were: 30 m × 0.25 mm, 0.25 μm for cocaine, heroin and benzodiazepines. 25 m × 0.25 mm, 0.25 μm was used for methamphetamine. The temperature programs were: i) for cocaine and heroin and benzodiazepine, starting temperature was 210 °C (hold time: 1 min), raised to 280 °C (increase rate: 25 °C/min; hold time: 1 min) and then 300 °C (increase rate: 25 °C/min; hold time: 1 min); ii) for methamphetamine, starting temperature was 100 °C (hold time: 1 min), raised to 125 °C (increase rate: 25 °C/min) and then 180 °C (increase rate: 15 °C/min). The carrier gas used was hydrogen set at the constant flow of 1 mL/min. The injection volume was 2 μL.
2.3.2. HPLC

The analysis were carried out using Varian Prostar 210 HPLC system. The columns were used 250 mm x 4 mm for cannabis and benzodiazepines and 160 mm x 5 mm was used for cocaine and heroin. A column with 300 mm x 5 mm, was used for methamphetamine and cathinone. In all cases, reverse phase columns (C18) were used. Detection was carried out by UV spectrophotometry at 240 nm, which is the wavelength closest to a major transition of cocaine, cannabis, heroin, benzodiazepine and methamphetamine. The mobile phase used was methanol:phosphate buffer (70:30 v/v), isocratic and the flow rate was 1 mL/min. The injected volume was 20 μl and the overall time for analysis was 20 min.

2.3.3. GC-MS

The GC–MS instrument used for the analysis was Varian 3800 GC system equipped with a triple quadrupole mass spectrometer. The column used was (30 m × 0.25 mm, 0.25 μm). The carrier gas used was helium operated at a constant flow of 1 mL/min. The acquisition was in full scan mode in the m/z range 40–450 and identification was by exploiting the NIST and SWGDRUG4 library. The oven program was; initial isotherm 60 °C for 3 min, 40 °C/min to 180 °C and 10 °C/min to 300 °C, final isotherm 300 °C for 10 min. Injector and transfer line temperatures were 275 °C and 280 °C, respectively. The injection volume was 1 μl in splitless mode.

3. Results and discussion

All drugs seized by the police force and other law enforcement agencies were submitted to GCLA for analysis. The confirmations of the drugs were achieved by both preliminary and confirmatory tests. Tables 1–3 and Figs. 1–3 show the distribution of number of cases, number of samples and total weights from 2011 to 2016. During that period of six years, a total of 90,366 samples corresponding to 2264 cases with a total weight of 17961.5 Kg were submitted and analysed at GCLA laboratories (Table 4; Fig. 4), an average of 15,061 samples corresponding to 2993.6 Kg per year.

Over the whole period of 2011–2016 cannabis emerged as the overall leading drug in terms of the number of cases, samples and total weight by 51.02%, 60.50% and 56.90%, corresponding to 1155, 54,668 and 10219.6 Kg, respectively (Tables 1–4; Figs. 1–4). However, between 2011 and 2015, heroin had the highest number of cases and number of samples with 58.46% and 55.91% of the total seizures, respectively, but cannabis was in leading in terms of weights of the seized illicit drugs followed by khat, heroin and cocaine. Benzodiazepines and ATS were in small amounts (Tables 1–3; Figs. 1–3). During that period of five years, the weight of cannabis was 61.97% of the total weight of drugs seized followed by khat with 32.61%. Heroin and cocaine had 4.02%, and 1.27% of the total weight seized, respectively (Table 3; Fig. 3). Figs. 1–4 show the percentage distribution of the number of cases, number of samples, weights and the overall summary. The trend of seizures for each year under investigation indicated ATS to be the lowest followed by benzodiazepines (Tables 1–4; Figs. 1–4).

In 2011 heroin was the leading drug in terms of the number of cases, number of samples and weight compared to any other illicit drug with 67.36%, 62.04% and 67.55% of the total number of cases, samples and total weight seized, respectively. Cocaine ranked second with 31.12% and 32.07% of the total number of samples and total weight, respectively. Cannabis was second in terms of the number of cases with 16% but its contribution to the number of samples was only 6.70% weighing 1.4 Kg. Benzodiazepines accounted for 0.14%, there were no khat and ATS samples seized in 2011 (Tables 1–3; Figs. 1–3).

A similar trend which showed heroin to have the highest percentages of the total number of cases and samples was observed in 2012 with corresponding values of 74.21% and 75.31%, respectively, followed by cannabis and cocaine (Tables 1 and 2; Figs. 1–2). However, heroin ranked second to cannabis in terms of the weights of the samples. Cannabis’ weight was 59.43% of the total weight compared to other illicit drugs (Table 3; Fig. 3). This was an increase in the weight of cannabis by 95.3 Kg and a significant decrease for both heroin and cocaine by 83.70% and 80.70%, respectively, compared to those in 2011, despite the fact that there was an increase by 67.79% in the number of heroin samples (Tables 2 and 3; Figs. 2–3). Cannabis cases remained the same but the number of samples increased by 298.29% from 234 to 932 in 2012 (Tables 1 and 2; Figs. 1–2). The number of cocaine cases and samples decreased by 57.14% and 77.37%, respectively, compared to the ones in the preceding year. Despite of the fact that the number of benzodiazepines cases decreased by 33.33% in 2012 but an increase by 120% in the number of samples was observed. The lowest was khat with 1 case, 3 samples weighing 0.4 Kg. There were no ATS cases in 2012.

In 2013, there were increases in the number of heroin cases and samples by 8.4% and 29.5%, respectively, compared to the preceding year. Conversely, the increases were not reflected in the weight of the samples which dropped by 11.6% (Tables 1–3; Figs. 1–3).

In the same year cannabis had the highest number of samples corresponding to 58.57% of the total number of samples resulting from the increase by 687.02% in the number of samples compared to 2012 (Table 2; Fig. 2). Likewise, the number of cannabis cases also increased significantly by 200% with a total weight of 4807.3 Kg resulting into a 126% increase in yearly cannabis case percentage relative to the total yearly drug cases.

On the contrary, the number of cocaine cases, samples and weight decreased sharply by 83.33%, 143.56% and 81.25%, respectively, compared to the previous years. The lowest were ATS and khat. There were no benzodiazepines cases. In general, apart from the observed decrease in seizures in some of the drugs but there were overall increases in the number of cases, samples and weights seized in 2013 (Tables 1–3; Figs. 1–3).

Apart from a slight decrease in the number of cases in 2014, but heroin still had the highest percentage of the number of cases compared to other drugs of abuse with 48.85% of the total number of cases followed by cannabis (27.69%) and khat (19.23%) (Table 1; Fig. 1). For

Table 1

| Year | Cannabis | Cocaine | Heroin | Khat | Benzodiazepines | ATS |
|------|----------|---------|--------|------|----------------|-----|
| 2011 | 52 (16.58%) | 28 (14.51%) | 130 (67.36%) | n/a | n/a | n/a |
| 2012 | 26 (16.35%) | 12 (7.55%) | 118 (74.21%) | 1 (0.63%) | 1 (1.55%) | n/a |
| 2013 | 78 (36.97%) | 2 (0.95%) | 128 (60.66%) | 2 (0.95%) | 2 (1.26%) | 1 (0.47%) |
| 2014 | 72 (27.69%) | 9 (3.46%) | 127 (48.85%) | 50 (19.23%) | 1 (0.38%) | 1 (0.47%) |
| 2015 | 71 (31.00%) | 2 (0.87%) | 112 (48.91%) | 41 (17.90%) | 3 (1.31%) | 1 (0.38%) |
| 2016 | 876 (72.28%) | 4 (0.33%) | 245 (20.21%) | 86 (7.10%) | 1 (0.08%) | 1 (0.38%) |

* Percentage based on the total number of cases for the corresponding year.
### Table 2
Distribution of number of samples of illicit drugs seized between 2011 and 2016.

| Number of samples (%) | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | Average |
|-----------------------|-------|-------|-------|-------|-------|-------|---------|
| Cannabis              | 234   | 932   | 7335  | 5133  | 1849  | 39,185| 9111.33 |
| Cocaine               | 1087  | 246   | 101   | 502   | 51    | 26    | 335.50  |
| Heroin                | 2167  | 3636  | 4710  | 5117  | 7812  | 6957  | 5066.50 |
| Khat                  | 2167  | 3636  | 4710  | 5117  | 7812  | 6957  | 5066.50 |
| Benzodiazepines       | 2167  | 3636  | 4710  | 5117  | 7812  | 6957  | 5066.50 |
| Total samples seized  | 3493  | 4828  | 12,524| 11,225| 9856  | 48,440| 15,061 |

b Percentage based on the total number of samples for the corresponding year.

### Table 3
Distribution of weight of samples of illicit drugs seized between 2011 and 2016.

| Weight of samples in Kg (%) | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | Average |
|-----------------------------|-------|-------|-------|-------|-------|-------|---------|
| Cannabis                    | 1.4   | 96.7  | 4807.3| 129.4 | 2699.4| 2485.4| 1703.3  |
| Cocaine                     | 117.8 | 22.8  | 4.2   | 14.3  | 4.0   | 5.4   | 27.4    |
| Heroin                      | 248.0 | 42.8  | 37.8  | 124.2 | 49.1  | 8.5   | 85.1    |
| Khat                        | -     | 0.4   | -     | 203.4 | 2050.9| 2973.3| 1733.8  |
| Benzodiazepines             | -     | -     | -     | -     | -     | -     | -       |
| Total weight seized         | 367.2 | 162.7 | 4865.5| 2285.5| 4799.4| 5481.2| 2993.6  |

*Weight not determined, sample in solution, mixed with soft drinks.

*c Percentage based on the total weight of the samples for the corresponding year.
cannabis, this was a decrease by 7.69% and 30.02% in the number of cases and samples, respectively, resulting into a drastic decrease in weight by 97.30% compared to 2013 (Tables 1–3; Figs. 1–3). The percentages of heroin and cannabis samples were similar in that year with 45.59% and 45.73%, respectively. On the other hand, an increase in the number of cocaine cases, samples and weight by 350%, 397.03% and 240.48%, respectively, was observed in 2014. A similar situation was observed in the number of khat cases, samples and weight. The number of cases increased significantly from 2 in 2013 to 50 cases in 2014 resulting into the increase in the number of samples and weight of khat by 23.7% and 2008.6 Kg, respectively. Khat was 88.09% of the total weight in 2014. The lowest for 2014 were ATS and benzodiazepines, each having 0.40% of the total number of cases (Tables 1–3; Figs. 1–3). The notable decrease in cannabis seizures could be associated with the efforts of the law enforcement agents in controlling farming, transportation and distribution of cannabis in the country.

In 2015 there was an increase in the number of heroin samples by 52.67%, followed by cannabis and khat (Table 2; Fig. 2). However, apart from the increase in the number of samples, a decrease in the number of heroin cases by 11.8% compared to those in the preceding year was also observed (Table 1; Fig. 1). Likewise, a slight decrease in the number of cannabis cases was observed in 2015 but the number of samples decreased significantly by 63.98% compared to 2014 (Table 2, Fig. 2). Despite the decrease in the number of samples seized, the weight of cannabis increased from 129.4 in 2014–2669.4 Kg in 2015 and accounted for 56.40% of the total weight seized in 2015 followed by khat with 42.73%. A similar observation was noted for khat where there was a decrease by 18% and 71.86% in the number of cases and samples, respectively. Although there was a decrease in both the number of khat cases and samples, there was a slight increase by 2.33% in the weight. The lowest were the benzodiazepines and cocaine, there were no ATS cases (Tables 1–3; Figs. 1–3). In 2016, cannabis had the highest number of cases and samples compared to other drugs of abuse with 72.28% and 80.89%, respectively, followed by heroin and khat. However, the weight of the seized samples was 2485.4 Kg ranking second to khat which weighed 2973.3 Kg. The 44.98% increase in weight of khat resulted from the increase in number of cases by 109.76% and number of samples from 130 in 2015–2264 in 2016 as compared to 2015. The lowest were benzodiazepines and cocaine, there were no ATS cases (Tables 1–3, Figs. 1–3). The
increase in the number of cases, samples and weight for cannabis and khat can be associated with the fact that both are locally cultivated products and they can easily be accessed. On the contrast, heroin and cocaine must be imported or illicitly produced in clandestine laboratories, where the raw materials for the synthesis are imported. In general, 2016 had the highest seizures in terms of number of cases, number
of samples and total weight as compared with the previous years (Tables 1–4; Figs. 1–4).

4. Conclusions

Through forensic analysis of illicit drugs seized during the 2011–2016 period, it was observed that in general, cannabis was the leading drug followed by khat, heroin and cocaine followed by far. Benzodiazepines and ATS were in minimal amounts. Cannabis had the highest percentage in all aspects, the number of cases, number of samples and weight compared to the rest of the other seizures with 51.19%, 60.50% and 56.90% of cases, samples and weight, respectively. The findings are in accordance with the literature as per the world drug report issued by UNODC in 2020, which showed cannabis to be the leading commonly used drug worldwide. Heroin ranked second with 37.93% cases and 33.64% samples; however, in terms of weight ranked third after khat, which was 39.21% of the total weight compared to 2.84% of heroin. Khat and cocaine each had less than 10% of both total number of cases and samples. Benzodiazepines and ATS seized were in very small amounts in terms of the number of cases, number of samples and weight for the whole period of study. According to the trend of the number of cases and samples seized during the period of the six years, there had been a significant decrease in heroin and cocaine cases, but an increase in the cannabis seizures. Over the six years, a decrease in cases and samples of both heroin and cocaine was observed, whereby in 2016, there were 0.33% cases and 0.05% samples of cocaine and 20.21% cases and 14.36% samples of heroin. These observations reflect on the increased government interception rates in collaboration with other international organizations in combating importation, transportation, and use of illicit drugs. However, on the other hand, for cannabis and khat, which are locally cultivated, more efforts still needed to combat the cultivation, transportation, and use due to the fact that they are easily accessible by many people because they are cheap, affordable and can easily be accessed by many users irrespective of their income. The trend had shown a steady decrease in semi-synthetic drugs and an increase in the naturally occurring drugs, cannabis and khat.

Credit authorship contribution statement

John J. Makangara: Conceptualization, Data collection and analysis, Writing - original draft, review and editing. Elias Z Mulima: Data collection and analysis and review.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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