World Drug Report 2021
Methodological Annex

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United Nations Office on Drugs and Crime

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1. Introduction

Considerable efforts have been made over the years to improve the estimates presented in the *World Drug Report,* which rely, to a large extent, on information submitted by Member States through the Annual Reports Questionnaire (ARQ). Nonetheless, challenges remain in producing such estimates because of the gaps and the varying quality in the available data. One major problem is the heterogeneity in the completeness and the time frame of data coverage in ARQs reported by Member States. Irregular reporting may result in absence of data for some years and may also influence the reported trend in a given year. In addition, submitted questionnaires are not always comprehensive, and much of the data collected are subject to limitations and biases. These issues affect the reliability, quality and comparability of the information received.

Sources of information

Under the International Drug Conventions, Member States are formally required to provide national drug control related information annually to the 'Secretary General' of the United Nations (i.e. the Secretariat in the UNODC). For this purpose, the Commission on Narcotic Drugs in 2010 endorsed the revised Annual Reports Questionnaire (ARQ) that is sent to Member States each calendar year for submission of responses and information on the drug situation.

The World Drug Report 2021 is based on data primarily obtained from the ARQs submitted by Governments to UNODC. The data collected in the current ARQ normally refer to the drug situation in 2019. Out of 200 potential respondents to the ARQ for 2019 (including 193 Member States), UNODC received 98 replies to its questionnaire on the "Extent and patterns of and trends in drug use (ARQ Part III)" and 105 replies to Part IV on "Extent and patterns and trends in drug crop cultivation, manufacturing and trafficking". Europe, had the best coverage (91 per cent of the respondents provided a reply), followed by Asia (58 per cent) and the Americas (56 per cent). In the case of Africa, only 23 per cent of the Member States, and in the Oceania region, only two out of the 16 countries, responded to the Annual Report Questionnaire.

In general, the quantity of information provided on illicit drug supply is slightly better than that of information provided on drug demand. Analysis of responses to Part IV of the ARQ revealed that 68 per cent of them were 'substantially' completed compared to 61 per cent of Part III (ARQs with completion rates higher than 50 per cent were classified as having been 'substantially filled in'; ARQs with completion rates lower than 50 per cent were classified as having been 'partially filled in').

In order to analyse the extent to which Member States provided information, a number of key questions in the ARQ were identified:

- For Part III, on the extent and patterns and trends of drug abuse, the key questions used for the analysis referred to: trends in drug use, for which 73 per cent of the respondents returning the ARQ provided information; prevalence of different drugs among the general population, for which 67 per cent of the respondents provided information; for prevalence of drug use among youth 60 per cent responded; for drug related mortality 55 per cent and for treatment demand 81 per cent. On average, for the countries which submitted Part III to UNODC, the overall response rate of completion was 61 per cent. However, this analysis does not take into account the completeness or quality of the information provided in response to each of the areas mentioned.

- For Part IV, on the extent and patterns and trends in drug crop cultivation, manufacturing and trafficking, the analysis included replies to the questions on: the quantities seized, for which 98 per cent of the Member States returning the ARQ provided the information; on trafficking of illicit drugs, for which 86 per cent of these Member States provided responses; on prices and purity 84 per cent of the Member States responded, and on persons brought into formal contact with the police and/or the criminal justice system in connection with drug-related offences, which 83 per cent of the Member States provided information. The overall analysis of these data revealed that the overall response rate completion was 62 per cent for Part IV. However, this analysis does not take into account the completeness of responses of the quality of information provided in each of sections mentioned.

Information provided by Member States in the ARQ form the basis for the estimates and trend analysis provided in the World Drug Report. Often, this information and data is not sufficient to provide an accurate or comprehensive picture of the world's drug markets. When necessary and where available, the data from the ARQ are thus supplemented with data from other sources.

As in previous years, seizure data made available to UNODC via the ARQ was complemented primarily with data from other government sources, such as other official communication with UNODC, official national publications, data provided to UNODC by the Heads of National Law Enforcement Agencies (HONLEA) at their regional meetings and data published by international and regional organisations such as Interpol/ICPO, World Customs Organization, European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) and the Inter-American Drug Abuse Control Commission (CICAD). Price data for Europe were complemented with data from Europol. Demand related information was obtained through a number of additional sources, including the national assessments of the drug situation supported by UNODC, the drug control agencies participating in the UNODC's 'Drug Abuse Information Network for Asia and the Pacific' (DAINAP), as well as various national and regional epidemiological networks such as the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) or the Inter-American Drug Abuse Control Commission (CICAD). Reports published by National governments and academic research published in the scientific literature were also used as additional sources of information. This type of supplementary information is useful and necessary to present an unbiased comprehensive picture of the drug situation as long as Member States lack the monitoring systems necessary to produce reliable, comprehensive and internationally comparable data.

To this end, UNODC encourages and supports the improvement of national monitoring systems. Major progress has been made in the area of illicit crop monitoring over the last few years in some of the countries that have major illicit crop cultivations. In close cooperation with UNODC and with the support of major donors – these countries have developed impressive monitoring systems designed to identify the extent of, and trends in, the cultivation of narcotic plants. These data form a fundamental basis for trend analysis of illicit crop cultivation and drug production presented in the World Drug Report.

There remain significant data limitations on the demand side. Despite commendable progress made in several Member States, in the area of prevalence estimates for example, far more remains to be done to provide a truly reliable basis for trend and policy analysis and needs assessments. The work currently being done on the World Drug Report provides yet another opportunity to emphasize the global need for improving the evidence base available to the policy makers and programme planners.

2. Drug use and health consequences

Data on drug use and health consequences

UNODC estimates of the extent of illicit drug use in the world have been published periodically since 1997. Assessing the extent of drug use (the prevalence and estimates of the number of drug users) is a particularly difficult undertaking because it involves in most settings measuring the size of a 'hidden' population. Regional and global estimates are reported with ranges to reflect the information gaps. The level of confidence expressed in the estimates varies across regions and drug types.

A global estimate of the level of use of a specific drug involves the following steps:

1. Identification and analysis of appropriate sources (starting from the ARQ);
2. Identification of key benchmark figures for the level of drug use in all countries where data are available (annual prevalence of drug use among the general population aged 15-64) which then serve as 'anchor points' for subsequent calculations;
3. 'Standardization' of existing data if reported with a different reference population than the one used for the *World Drug Report* (for example, from age group 12 and above to a standard age group of 15-64);
4. Adjustments of national indicators to estimate an annual prevalence rate if such a rate is not available (for example, by using the lifetime prevalence or current use rates; by aggregating prevalence of two drug types, like use of amphetamine and methamphetamine to obtain the joint estimates of prevalence of use for the overall amphetamines; or extrapolating from lifetime or annual prevalence rates among the youth population to the adult population. The latter includes the identification of adjustment factors based on information from countries in the region with similar cultural, social and economic situations where applicable;
5. Imputation for countries where data are not available, based on data from countries in the same subregion. Ranges are calculated by considering the 10th and 90th weighted

percentile of the subregional distribution, using the target population in the countries as weights;

6. Extrapolation of available results for a subregion were calculated only for subregions where prevalence estimates for at least two countries covering at least 20% of the population were available. If, due to a lack of data, subregional estimates were not extrapolated, a regional calculation was extrapolated based on the 10th and 90th percentile of the distribution of the data available from countries in the region. Since the World Drug Report 2019, when this methodology was revised, a weighted percentile procedure has been used that takes into account the population aged 15-64 in the countries;

7. Aggregation of subregional estimates rolled-up into regional results to arrive at global estimates.

For countries that did not submit information through the ARQ, or in cases where the data were older than 10 years, other sources were identified, where available. In nearly all cases, these were government sources. Many estimates needed to be adjusted to improve comparability (see below).

In cases of estimates referring to previous years, the prevalence rates are unchanged and applied to new population estimates for the year 2019. Currently, only a few countries measure prevalence of drug use among the general population on an annual basis. The remaining countries that regularly measure it - typically the more economically developed - do so usually every three to five years. Therefore, caution should be used when interpreting any change in national, regional or even global prevalence figures, as changes may in part reflect newer reports from countries, at times with changed methodology, or the exclusion of older reports, rather than actual changes in prevalence of a drug type.

Detailed information on drug use is available from countries in North America, a large number of countries in Europe, a number of countries in South America, the two economically most advanced countries in Oceania and a limited number of countries in Asia and Africa. For the World Drug Report 2021, new estimates of prevalence of drug use among the general population for the year 2019 were available for 12 countries, of which two of them already reported 2019 data for the previous World Drug Report.

One key problem in national data is the level of accuracy, which varies strongly from country to country. Not all estimates are based on sound epidemiological surveys. In some cases, the estimates simply reflect the aggregate number of drug users found in drug registries, which cover only a fraction of the total drug using population in a country. Even in cases where detailed information is available, there is often considerable divergence in definitions used, such as chronic or regular users; registry data (people in contact with the treatment system or the judicial system) versus survey data (usually extrapolation of results obtained through interviews of a selected sample); general population versus specific surveys of groups in terms of age (such as school surveys), special settings (such as hospitals or prisons), or high risk groups, et cetera.

To reduce the error margins that arise from simply aggregating such diverse estimates, an attempt has been made to standardize - as a far as possible - the heterogeneous data set. All available estimates were transformed – as far as feasible - into one single indicator – annual prevalence among the general population aged 15 to 64 – in most instances using regional average estimates and using transformation ratios derived from analysis of the situation in neighbouring countries. The basic assumption is that though the level of drug use differs between countries, there are general patterns found for the psychoactive substances for which regional and global estimates are generated (for example, young people consume more drugs than older people; males consume more drugs than females; people in contact with the criminal justice system show higher prevalence rates than the general population, et cetera) which apply to most countries. It is also assumed that the relationship between lifetime prevalence and annual prevalence among the general population or between lifetime prevalence among young people and annual prevalence among the general population, except for new or emerging drug trends, do not vary greatly among countries with similar social, cultural and economic situations.

UNODC does not publish estimates of the prevalence of drug use in countries with smaller populations (less than approximately 100,000 population aged 15-64) where the prevalence estimates were based on the results of youth or school surveys that were extrapolated to the general adult population, as applying such methods in the context of small countries can result in inaccurate figures.

Indicators

The most widely used indicator at the global level is the annual prevalence rate: the number of people who have consumed an illicit drug at least once in the twelve months prior to the study. Annual prevalence has been adopted by UNODC as one of key indicators to measure the extent of drug use. It is also part of the Lisbon Consensus on core epidemiological indicators of drug use which has been endorsed by the Commission on Narcotic Drugs. The key epidemiological indicators of drug use are:

1. Drug use among the general population (prevalence and incidence);
2. Drug use among the youth population (prevalence and incidence);
3. High-risk drug use (number of injecting drug users and the proportion engaged in high-risk behaviour, number of daily drug users);
4. Utilization of services for drug problems (treatment demand);
5. Drug-related morbidity (prevalence of HIV, hepatitis B virus and hepatitis C virus among drug users);
6. Drug-related mortality (deaths attributable to drug use).

Efforts have been made to present the overall drug situation from countries and regions based on these key epidemiological indicators.

The use of annual prevalence is a compromise between lifetime prevalence data (drug use at least once in a lifetime) and data on current use (drug use at least once over the past month). The annual prevalence rate is usually shown as a percentage of the youth and adult population. The definitions of the age groups vary, however, from country to country. Given a highly skewed distribution of drug use among the different age cohorts in most countries, differences in the age groups can lead to substantially diverging results.

Applying different methodologies may also yield diverging results for the same country. In such cases, the sources were analysed in-depth and priority was given to the most recent data and to the methodological approaches that are considered to produce the best results. For example, it is generally accepted that nationally representative household surveys are reasonably good approaches to estimating cannabis, ATS or cocaine use among the general population, at least in countries where there are no adverse consequences for admitting illicit drug use. Thus, household survey results were usually given priority over other sources of prevalence estimates.

When it comes to the use of opiates (opium, heroin, and other illicit opiates), injecting drug use, or the use of cocaine and ATS among regular or dependent users, annual prevalence data derived from national household surveys tend to grossly under-estimate such use, because heroin or other problem drug users often tend to be marginalized or less socially integrated, and may not be identified as living in a 'typical' household (they may be on the streets, homeless or institutionalized). Therefore, a number of 'indirect' methods have been developed to provide estimates for this group of drug users, including benchmark and multiplier methods (benchmark data may include treatment demand, police registration or arrest data, data on HIV infections, other services utilization by problem drug users or mortality data), capture-recapture methods and multivariate indicators. In countries where there was evidence that the primary 'problem drug' was opiates, and an indirect estimate existed for 'problem drug use' or injecting drug use, this was preferred over household survey estimates of heroin use. Therefore, for most of the countries, prevalence of opioid or opiates use reported refers to the extent of use of these substances measured through indirect methods.

For other drug types, priority was given to annual prevalence data found by means of household surveys. In order to generate comparable results for all countries, wherever needed, the reported data was extrapolated to annual prevalence rates and/or adjusted for the preferred age group of 15-64 for the general population.

Extrapolation methods

Adjustment for differences in age groups

Member States are increasingly using the 15-64 age group, though other groups are used as well. Where the age groups reported by Member States did not differ significantly from 15-64, they were presented as reported, and the age group specified. Where studies were based on significantly different age groups, results were typically adjusted. A number of countries reported prevalence rates or number of drug users for the age groups 15+ or 18+. In such cases, adjustments were generally based on the assumption that there was no significant drug use above the age of 64; the reported number of drug users based on the population age 15+ (or age 18+) was shown as a proportion of the population aged 15-64.

Methodology to produce joint estimates for more than one types of drugs

In the collection of information on prevalence of drug use, a number of instances arise where data are available for specific types of drugs, but prevalence data are needed at a higher level of aggregation. In other words, prevalence data may be available for two particular kinds of drugs but may also be needed in the form of a single figure which takes into account both types at the same time. This is especially relevant in the case of closely related types of drugs. For example, the prevalence of use of cocaine salts and "crack" cocaine may be known, but in addition the prevalence of cocaine in general may be needed. If no empirical data is available from Member States, a joint estimate is produced by aggregating the different types of drugs according to the following method.

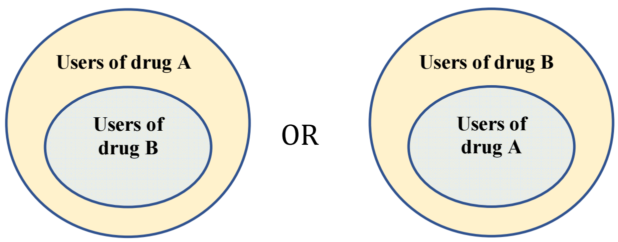
The methodology to calculate the estimate for prevalence of use of two drugs considers the extent to which the group of users of one drug overlaps with the group of the users of the other drug, for the same reference period (i.e. lifetime, past year or past month).

The prevalence rates of two types of drugs are combined to obtain the estimate of the prevalence of any of the two drugs, which is derived as the midpoint of a lower (minimum) estimate and an upper (maximum) estimate. These two estimates represent two opposite extreme scenarios: in one scenario all the users of one type of drug also consume the other drug, whereas in the other scenario none of the persons consuming the first drug consume the other drug (and vice versa).

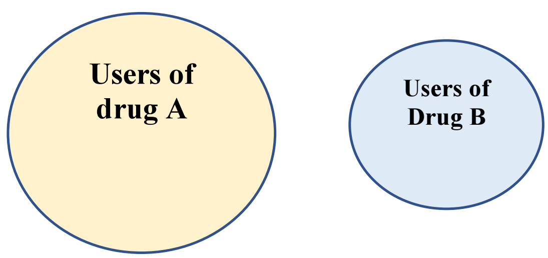
Given any two drugs A and B, we denote by P_A and P_B the prevalence of use of drugs A and B, respectively. We aim to obtain an estimate of the prevalence of use of at least one of the drugs A and B (e.g. use of cocaine = use of cocaine salts or crack cocaine). We shall call this value $Z = P_{A\&B}$.

The lower estimate (Z_{min}) corresponds to the scenario where all the users of one drug are to be found among the users of the other drug. Therefore, the lower (minimum) joint estimate corresponds to the highest value (maximum) among the two values of prevalence.

$\mathbf{Z_{min} = max\ (P_A, P_B)}$

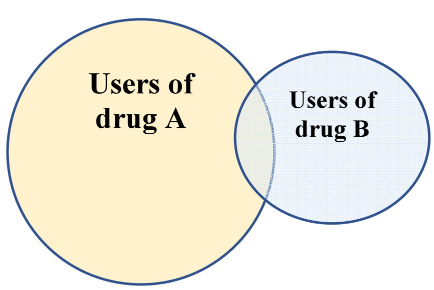


The upper (maximum) joint estimate reflects the opposite scenario, where the group of users of drug A is completely separate from the group users of drug B; that is, none of the users of drug A consume drug B (and vice versa).



Therefore, the upper (maximum) joint estimate for the two drugs is the sum of the prevalence of the drug A and drug B; in other words, $\mathbf{Z_{max} = P_A + P_B}$.

The best estimate is obtained as the midpoint between Z_{min} and Z_{max}; that is $\mathbf{Z_{best} = (Z_{max} + Z_{min})/2}$. This represents a scenario in between the two extremes, where some of drug A users consume also drug B.



Extrapolation of results from lifetime prevalence to annual prevalence

Some countries have conducted surveys in recent years without asking the question whether drug consumption took place over the last year. In such cases, results were extrapolated to reach annual prevalence estimates. For example, country X in West and Central Europe reported a lifetime prevalence of cocaine use of 2%. As an example, taking data for lifetime and annual prevalence of cocaine use in countries of West and Central Europe, it can be shown that there is a strong positive correlation between the two measures (correlation coefficient $R = 0.94$); that is, the higher the lifetime prevalence, the higher the annual prevalence and vice versa. Based on the resulting regression line (with annual prevalence as the dependent variable and lifetime prevalence as the independent variable) it can be estimated that a country in West and Central Europe with a lifetime prevalence of 2% is likely to have an annual prevalence of around 0.7% (see figure). Almost the same result is obtained by calculating the ratio of the unweighted average of annual prevalence rates of the West and Central European countries and the unweighted average lifetime prevalence rate (0.93/2.61 = 0.356) and multiplying this ratio with the lifetime prevalence of the country concerned (2% * 0.356 = 0.7%).

Example of annual and lifetime prevalence rates of cocaine use in West and Central Europe

Sources: UNODC, Annual Reports Questionnaire Data / EMCDDA, Annual Report.

A similar approach was used to calculate the overall ratio by averaging the annual/lifetime ratios, calculated for each country. Multiplying the resulting average ratio (0.387) with the lifetime prevalence of the country concerned provides the estimate for the annual prevalence (0.387 * 2% = 0.8%). There is a close correlation observed between lifetime and annual prevalence (and an even stronger correlation between annual prevalence and monthly prevalence). Solid results (showing small potential errors) can only be expected from extrapolations done for a country in the same region. If instead of using the West and Central European average (0.387), the ratio found in the USA was used (0.17), the estimate for a country with a lifetime prevalence of cocaine use of 2% would instead amount to 0.3% (2% * 0.17). Such an estimate is likely to be correct for a country with a drug history similar to the USA, which has had a cocaine problem for more than two decades, as opposed to West and Central Europe, where a significant cocaine problem is largely a phenomenon of the last decade. Therefore, data from countries in the same subregion with similar patterns in drug use were used, wherever possible, for extrapolation purposes.

Both approaches—the regression model and the ratio model—were used to determine upper and lower uncertainty range estimates calculated at a 90% confidence interval among those aged 15-64 years in the given country. The greater the range, the larger the level of uncertainty around the estimates. The range for each country is reported in the statistical annex, where available.

Extrapolations based on school surveys

Analysis of countries which have conducted both school surveys and national household surveys shows that there is, in general, a positive correlation between the two variables, particularly for cannabis, ATS and cocaine. The correlation, however, is weaker than that of lifetime and annual prevalence or current use and annual prevalence among the general population. But it is stronger than the correlation between opiate use and injecting drug use and between treatment demand and extent of drug use in the general population

These extrapolations were conducted by using the ratios between school surveys and household surveys of countries in the same region or with similar social structure where applicable. As was the case with extrapolation of results from lifetime prevalence to annual prevalence, two approaches were taken: a) the unweighted average of the ratios between school and household surveys in the comparison countries with an upper and lower uncertainty range estimate calculated at a 90% confidence interval; and b) a regression-based extrapolation, using the relationships between estimates from the other countries to predict the estimate in the country concerned, with an upper and lower uncertainty range estimate calculated at a 90% confidence interval. The final uncertainty range and best estimate are calculated using both models, where applicable.

Extrapolations based on treatment data

For a number of developing countries, the only drug use-related data available was drug users registered or treatment demand. In such cases, other countries in the region with a similar socio-economic structure were identified, which reported annual prevalence and treatment data. A ratio of people treated per 1,000 drug users was calculated for each country. The results from different countries were then averaged and the resulting ratio was used to extrapolate the likely number of drug users from the number of people in treatment.

National, regional and global estimates of the number of people who use drugs and the health consequences of drug use

For this purpose, the estimated prevalence rates of countries were applied to the population aged 15-64, as provided by the United Nations Population Division for the year 2019.

In the tables presented in the World Drug Report for regional and global estimates, totals may not add up due to rounding.

Ranges have been produced to reflect the considerable uncertainty that arises when data are either extrapolated or imputed. Ranges are provided for estimated numbers and prevalence rates in the Report. Larger ranges are reported for subregions and regions with less certainty about the likely levels of drug use – in other words, those regions for which fewer direct estimates are available, for a comparatively smaller proportion of the region's population, or for regions for which the existing estimates show a comparatively larger variability.

Countries with one published estimate (typically those countries with a representative household survey, or an indirect prevalence estimate that did not report ranges) did not have uncertainty estimated. This estimate is reported as the 'best estimate'.

To account for populations in countries with no published estimate, the 10th and 90th percentile in the range of direct estimates within the subregion was used to produce a lower and upper estimate. Similarly to the World Drug Report 2020 in this report a weighted percentile procedure was implemented, that takes into account the population in the 15-64 age group in each country. For example, there are four countries in the Near and Middle East / South-West Asia subregion with sufficiently recent past year prevalence estimates for cocaine use: Afghanistan (0.00 per cent, a point estimate), Iran (Islamic Republic of) (0.00 per cent – 0.22 per cent , best estimate 0.11 per cent), Israel (0.50 per cent – 0.70 per cent, best estimate 0.60 per cent) and Pakistan (0.00 per cent – 0.04 per cent, best estimate 0.01 per cent). In order to obtain a best estimate for the subregion, the weighted average of the best estimates for prevalence over these three countries is applied to the population of the remaining countries in the subregion without prevalence data. To obtain a range for the subregion, the weighted 10th percentile of the lower bounds of the uncertainty ranges (0.00 per cent, 0.00 per cent, 0.50 per cent and 0.00 per cent), namely 0.00%, and the 90th percentile of the upper bounds (0.00 per cent, 0.22 per cent, 0.70 per cent and 0.04 per cent), namely 0.21 per cent, were considered. It is important to note that, as Israel accounts for only about 3 per cent of the population within the 15-64 age group in these four countries, the resulting weighted percentiles are not heavily influenced by the higher prevalence present in this country. The percentages of 0.00 and 0.21 were applied to the population of the remaining countries without prevalence data, in combination with the national level data for Afghanistan, Iran (Islamic Republic of), Israel and Pakistan, to derive subregional lower and upper estimates of 0.01 and 0.13 per cent respectively.

In some cases, not all the regions in a subregion had sufficient country-level data to allow the above calculations. In such cases, for the purposes of arriving at estimates at regional level, lower and upper estimates at the sub-regional level were derived based on the data points from the entire region, specifically by considering the weighted 10th and 90th percentiles respectively of the lower and upper country-level estimates. These results were then combined with the other subregions to arrive at upper and lower estimates, and hence best estimates, at regional level.

This produces conservative (wide) intervals for subregions where there is geographic variation and/or variance in existing country-level estimates; but it also reduces the likelihood that skewed estimates will have a dramatic effect on regional and global figures, as the weighted percentiles procedure will give a smaller weight to relatively small countries, which tend to be more likely to present an extreme prevalence.

As in the World Drug Report 2020 in this report the region of Oceania was divided into four subregions (Australia and New Zealand, Melanesia, Micronesia, and Polynesia), while in previous years prior to 2018 no subregional estimates of annual prevalence among the population aged 15-64 were available. Given that the data for Melanesia, Micronesia and Polynesia is scarce, in order to avoid imputing these regions with data from only Australia and New Zealand (which are highly developed and thus very different from most other countries in Oceania), the closest five countries to these regions with available data were considered in the calculations, when necessary. This was the case for the calculations of the prevalence of cocaine, “ecstasy”, opiates and opioids.

Estimates of the total number of people aged 15-64 who used illicit drugs at least once in the past year

This year's Report used the same approach as in the previous years. Two ranges were produced, and the lowest and highest estimate of each approach was taken to estimate the lower and upper ranges, respectively, of the total drug using population. This estimate is obviously tentative given the limited number of countries upon which the data informing the two approaches were based. The two approaches were as follows:

Approach 1:

The global estimates of the number of people using each of the five drug groups in the past year were added up. Taking into account that people use more than one drug type and that these five populations overlap, the total was adjusted downward. The size of this adjustment was made based upon household surveys conducted in 29 countries globally including countries from North America (Canada, Mexico and the United States of America), Europe (including Italy, Germany, Spain and England and Wales), Latin America (Argentina, Brazil, Plurinational State of Bolivia, Chile, Costa Rica, El Salvador and Uruguay), Asia and the Pacific (Israel, Indonesia, Philippines, Thailand and Australia) and Africa (Algeria, Nigeria), which assessed all five drug types, and reported an estimate of total illicit drug use. Across these studies, the extent to which adding each population of users overestimated the total population was a median factor of 1.14. The summed total was therefore divided by 1.14 to arrive at an estimate of the global number of drug users.

Approach 2:

This approach was based on the average proportion of the total drug using population that used cannabis as a strong positive correlation between cannabis use and overall drug could be identified. The average proportion was obtained from household surveys conducted in the same countries as for Approach 1. Across all of these studies, the median proportion of cannabis users to total drug users was 80.9 per cent. The range of cannabis users at the global level was therefore divided by 0.809 to arrive at an estimate of the global number of drug users.

The global lower estimate was the lower of the two values obtained from the two approaches, while the upper estimates was the upper value derived from the two approaches described. The average of the two values was reported as best estimate.

Estimates of the number of people suffering from drug use disorders ('problem drug users')

It is useful to make estimates of the number of drug users whose use is particularly problematic, as a proxy to those who could be diagnosed with drug use disorders, as this subgroup of drug users is most likely to come to the attention of health and law enforcement. Moreover, this subgroup's drug use has been estimated to cause the main burden of disease and public order.

The number of "*people suffering from drug use disorders" was previously referred to as "*problem drug users". i Alternative approaches are usually used to estimate such numbers. iThe EMCDDA has been using a definition of 'injecting or long duration use of opioids, amphetamines or cocaine' to guide country-level indirect prevalence estimation studies of problem drug use. Indirect methods used include the use of treatment multipliers and capture re-capture methods.

In this Report, as in previous years, each of the five range estimates of the number of people using each of the five drug groups was converted into a 'heroin user equivalent'. This was calculated with 'relative risk coefficients' (see below) derived from the UNODC Harm Index. This method enables the aggregation of results from different drugs into one reference drug.

Table: Relative risk coefficient

	Treatment index	**IDU**	**Toxicity**	**Deaths index**	**Relative risk coefficient**
		Index	Index		(average treatment, IDU, toxicity, death)
Opiates	100	100	100	100	**100**
Cocaine	85.3	47.8	88	18.5	**59.9**
Amphetamines	20.1	59.5	32	6.8	**29.6**
Ecstasy	3.8	6.1	20.7	1	**7.9**

Cannabis	9	0	1.5	0.6	**2.8**

A lower range was calculated by summing each of the five lower range estimates; the upper end of the range was calculated by summing the upper range of the five estimates.

To obtain an estimate of the number of 'problem drug users' (i.e. an estimate of the number of people suffering from drug use disorders), these totals were multiplied by the corresponding proportion of dependent heroin users (DSM-IV) among past year heroin users in the United States National Survey on Drug Use and Health (range 53-68% over a five year period). Hence, the LOW estimate is the lower proportion (53%) multiplied by the lower estimated size of the heroin use equivalent population (36.9 million heroin user equivalents in 2019). The HIGH estimate is the higher proportion (68%) multiplied by the higher estimated size of the heroin use equivalent population (78.0 million heroin user equivalents in 2019). This gives a range of 19.6 to 53.0 million problem drug users or people suffering from drug use disorders globally.

Calculation of regional and global estimates of cannabis use among 15-16 years old students, and estimates of any illicit drug use among 15-16 years old students

In 2018, UNODC undertook in the World Drug Report – for the first time – an estimate of the annual prevalence of cannabis use among 15-16 years old students, based on available data from 130 countries. Starting from 2019, the World Drug Report presents also estimates of any illicit drug use prevalence among 15-16 years old students.

The age group "15-16 years" was chosen as this is the "preferred" age group for "youth" that is asked in UNODC's annual report questionnaire. This age group was also chosen by ESPAD which regularly provides data from some 35 European countries on drug and alcohol use. This age group is also available from the surveys among 10th graders undertaken annually under the Monitoring the Future project in the United States, funded by the National Institute on Drug Abuse (NIDA), and from a number of other countries.

Cannabis use prevalence rates typically increase with age until around 18-20 years before declining again thereafter with age. This also means that for most countries cannabis use prevalence rates among 15-16 years old students turn out to be rather similar to the broader group of students aged 12-18 (with those aged 12-14 showing lower rates and those aged 17-18 showing higher rates). Thus, for the United States the annual cannabis use prevalence rates amongst 10th graders turn out to be very similar to those found amongst 8th, 10th and 12th graders combined. Similarly, in Colombia annual prevalence of cannabis use amongst 12 to 18 years old students was found to have been very similar to the rates found among 15-16 years old students. The same applies to students in Pakistan as well. Cannabis use prevalence rates among students aged 15-16 are thus reasonably good proxies for cannabis use among the overall student population aged 12-18. They are thus the preferred indicator for measuring student drug use at the international level as is also reflected in the question on student drug use in UNODC's annual report questionnaire.

The methodology chosen to calculate the global average of cannabis use among students aged 15-16 years was very similar to the methodology used to calculate cannabis use among the general population aged 15-64:

1. Listing – on a sub-regional basis – the latest annual prevalence rates of cannabis use among the population aged 15-16 (which in most cases reflected school surveys) and multiplying such percentages with the average population of those aged 15-16 in those countries in 2019.

2. For the remaining countries that reported prevalence data on cannabis use (but not the requested age group or not annual prevalence), the following adjustments/extrapolations were done:

    a. Adjusting surveys using different age groups to a likely estimate for the population aged 15-16 years; the age adjustments were done based on detailed data from the United Stated for countries in North America, Europe and the developed countries of the Oceania region (i.e. Australia and New Zealand); for Africa and Asia based on detailed data available from Pakistan and for South America, Central America and the Caribbean based on detailed data available from Colombia.

    A special model was developed for the adjustments. Taking into account considerations of diversity and representativity, the following data served as benchmarks for the calculation of the conversion ratios: the 2013 survey in

Colombia among people aged 12-65[1], the 2012 survey carried out in Pakistan jointly by UNODC and the Government of Pakistan targeting the population aged 15-64[2] and the 2015 National Survey on Drug Use and Health of the United States among people aged 12 years and older[3]. After collating or generating prevalence data broken down by age groups, prevalence data were derived for each single-year age group. In cases where robust data were not available at this level of granularity (e.g. prevalence data available only for the age brackets 15-19, 20-24, 25-29, etc.), the prevalence in single-year age groups was estimated by optimizing for smoothness the prevalence data as a function of age - subject to the constraints that the total number of users within each given age bracket remained unchanged (i.e. equal to the prevalence multiplied by the population within the specific age bracket). Where necessary boundary conditions were imposed, e.g. a prevalence of 0 for ages 10 and below. On the basis of single-year prevalence estimates obtained, the prevalence rates were estimated for each possible age group that could potentially arise (e.g. 10-15, 12-19, 14-22). Finally, the conversion factors were calculated as the ratios of the prevalence data within the respective age groups as compared to the age groups of interest (age 15-16 years).

b. Extrapolating available life-time or past month data of cannabis use from individual countries to (missing) annual prevalence data based on a regression analysis of other countries in the subregion providing both life-time and annual data among youth or both past month and annual data among youth. A 95 per cent confidence interval was then used to calculate, in addition, a minimum and a maximum estimate based on such regression data.

3. For the remaining countries which did not report any prevalence data it was assumed that – on average – they had similar prevalence rates as the population weighted average of the reporting countries in the subregion. In cases where the reporting countries accounted for less than 20 per cent of the total population of the subregion,

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[1] *Gobierno Nacional de la República de Colombia, Estudio Nacional de Consumo de Sustancias Psicoactivas en Colombia – 2013.*

[2] UNODC, *Drug Use in Pakistan 2013.*

[3] Data query engine at http://pdas.samhsa.gov/ and *Substance Abuse and Mental Health Services Administration, Results from the 2015 National Survey on Drug and Health: Detailed Tables*.

the (weighted) average of reporting countries in the region as a whole was used instead.

4. For countries not reporting any prevalence data it was assumed that the lower estimate was equivalent to the (population weighted) 10^{th} percentile of the reporting countries in the subregion (or the region if reporting countries in the subregion accounted for less than 20 per cent of total population in the subregion) while the upper estimate was equivalent to the (population weighted) 90^{th} percentile of the reporting countries in the subregion (or the data for the region was used as a proxy if reporting countries in the subregion accounted for less than 20 per cent of the total population in the subregion).

   The reported ranges reflected primarily the coverage of a region by student surveys; in short, the larger the reported error margins, the less countries reported school survey data in a region or sub-region to UNODC. Error margins turned out to be small for Europe and the Americas where a majority of countries undertook such school surveys in recent years while they were rather large for Africa, Asia or for the Oceania region (with the exception of the economically advanced countries in this region).

5. The totals of the calculated subregional estimates gave the regional estimates and the total of the regional estimates then gave the global estimates.

6. The number of cannabis users was shown for a hypothetical average age of 15-16 years; in order to calculate the total number of cannabis users of those aged 15 years and 16 years the totals had to be still multiplied by two (in order to be in line with the approach used to show general population estimates for those aged 15-64)

As mentioned before, UNODC also computed an estimate on the number of users aged 15-16 worldwide that have consumed any illicit drug in the last 12 months. The methodology used for this estimate replicates the approach through which the prevalence of any illicit drug use is calculated for the general population aged 15-64, as previously described.

As explained, this methodology examines the relationship between cannabis use prevalence and any illicit drug use prevalence in the target population to estimate the latter based on the former. The analysis of information from 51 different countries, representing South, Central and North America, Europe, Oceania and Asia, yields that the observed median ratio between cannabis and any illicit drug use annual prevalence for the target population is 90 per cent. Based on this, the total number of any illicit drug users in the 15-16 age group worldwide was estimated directly from the global estimate of cannabis drug users in the same age group.

Estimates of the prevalence of injecting drug use, HIV and hepatitis (C and B virus) among people who inject drugs (PWID)

Data sources, selection of country estimates and validation process

Population size estimates for PWID, and the prevalence of HIV and hepatitis among PWID, were identified over the past six years using a comprehensive search of the published peer-reviewed literature, a search of the "grey" literature, from the official United Nations survey instruments of UNODC and UNAIDS, from regional organizations (particularly the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA)), and through the global network of UNODC HIV/AIDS Advisors.

The criteria for the selection of country estimates primarily involved the consideration of the methodological soundness of the estimates, determined according to the classification presented in the table below (studies in class A are of higher methodological quality and those in class D of lower quality), with due regard to national geographic coverage, the year of the estimate, and the definition of the target population (global and regional estimates were made for the annual prevalence of injecting among both genders aged 15-64). UNODC, WHO, UNAIDS and the World Bank reviewed all estimates.

Table: Classification of methodology for people who inject drugs, and those among them living with HIV and hepatitis

Data are categorized by methodology according to a slightly modified classification originally proposed in Mathers et. al. (2008) Lancet paper.[4]

Class	*Data on people who inject drugs*
A	Indirect prevalence estimation methods e.g., capture-recapture, network scale-up method, multiplier methods, etc
B1	Mapping/census and enumeration
B2	General population survey
C	Treatment and other national registers of drug users
D1	· Official government estimate with no methodology reported · Experts' judgment with known method of estimation (eg. an estimate obtained through a rapid assessment) · Modelling studies (e.g. Spectrum) · Delphi method or other consensus estimate
D2*	Estimate from non-official source with methodology unknown

Class	*Data on the prevalence of HIV and hepatitis among people who inject drugs*
A	Seroprevalence study
A1	Multi-site seroprevalence study with at least two sample types (e.g. treatment or outreach sample)
A2	Seroprevalence study from a single sample type
B	Registration or notification of cases of HIV infection (e.g. from treatment services)
C	Prevalence study using self-reported HIV
D1	· Official government estimate with no methodology reported · Modelling Studies (e.g. mode of transmission models)
D2*	Estimate from non-official source with methodology unknown

* Data graded D2 are excluded from the dataset

As part of a wider review process, every year since 2014, UNODC, WHO, UNAIDS and the World Bank have reached out to a broad group of experts from academia (including all former members of the Reference Group to the United Nations on HIV and Injecting Drug Use) and regional, international, including civil society, organizations to ensure that a scientific approach to the methodology was used and that the greatest number of datasets available worldwide on the subject were included. Data were sent to Member States as part of the prepublication for their validation and potential comments on the selected estimates, or for completion of data if there were national estimates based on surveys or studies that had been conducted and which UNODC was not aware of.

[4] Mathers, B., L. Degenhardt, et al. (2008). Global epidemiology of injecting drug use and HIV among people who inject drugs: a systematic review. *The Lancet* 372(9651): 1733-1745

Calculation of regional and global estimates

Regional and global estimates were calculated for the reference year 2019 (as most of the data presented in the World Drug Report 2021 is for the reference year 2019.).

The regional best estimates for the prevalence of injecting drug use, and HIV and hepatitis among PWID, were calculated as the population-weighted means. The global estimates for 2019 were calculated as the population-weighted regional means. In the population-weighting procedure, the population refers to those aged 15-64 years for the year 2019 in the case of the prevalence of people who inject drugs , or to the estimated number of PWID for the year 2019 in the case of the prevalence of HIV and hepatitis among PWID. For countries where a number (as size estimate) of PWID was reported in the study/survey, a prevalence estimate was subsequently calculated using the population aged 15-64 corresponding to the year of the estimate. For those countries where an estimate of the prevalence of HIV or hepatitis among PWID was available, but a population size estimate for PWID was not, then the regional weighted average prevalence of people who inject drugs was used to produce a population size estimate for PWID that was used in the weighting procedure for the prevalence of HIV and hepatitis among PWID.

Uncertainty intervals for the regional and global best estimates were calculated that reflect both the range in the country prevalence estimates (if these were available) and the regional variability in the available country prevalence estimates. To achieve this, the 10th and 90th percentiles of the known prevalence estimates for countries from within the same region were determined. These were then applied to countries from within the same region for which no estimates were available to give a range of plausible population size estimates. This produced a liberal uncertainty range while excluding the extreme prevalence estimates.

Data quality of estimates on people who inject drugs and HIV among PWID

Interpretation of regional and global estimates

The global and regional estimates for the prevalence of people who inject drugs and HIV among PWID presented for 2019 in the *World Drug Report* should be viewed as an update to those presented in previous editions of the *World Drug Report* that reflect the latest or the best data available. This year new or updated information on size estimates of PWID was available from 23 countries and on HIV among PWID from 31 countries. The current estimates, though unchanged from the previous year, represent the best estimates that can currently be made using the most recent and highest quality data available to UNODC, WHO, UNAIDS, and the World Bank based on data reported by Member States, published or grey literature or through other stakeholders.

Quality of national-level data on PWID

Of the 121 countries with information on the prevalence of PWID, 62 per cent were of high methodological quality (class A, as defined in the table above) and 74 per cent related to timely data from 2014 or more recently. Almost one-half (45 per cent) of the countries have information that is from recent, methodologically high-zquality surveys. With a low level of coverage of the population aged 15-64 compared to other regions there is limited information on PWID for countries in Africa. It is noticeable that there are relatively few recent, methodologically high-quality data from the Americas. However, for the two sub-regions with the highest prevalence of PWID (Eastern and South-Eastern Europe, and Central Asia and Transcaucasia) there is a very high percentage data coverage of the populations aged 15-64 and approximately one half or more of the estimates are both recent and of high methodological quality.

Quality of national-level data on HIV among PWID

Of the 121 countries with information on the prevalence of HIV among PWID, 72 per cent were of high methodological quality (class A, as defined in the table above) and 55 per cent related to timely data from 2015 or more recently. More than one third (35 per cent) of the countries have information that is from both recent and methodologically high-quality surveys. The two sub-regions that have by far the highest prevalence of HIV among PWID (South-West Asia, and Eastern and South-Eastern Europe) have prevalence estimates from all countries and from methodologically high-quality surveys from a good percentage of those countries.

Table: Population coverage, timeliness and methodological quality of information from the 121 countries with data on people who inject drugs

Region	Subregion	People who inject drugs		Of countries with available estimates		
		Data coverage of population aged 15-64	Data coverage in terms of countries	Percentage with recent data (2014 and later)	Percentage with high methodoligcal quality estimes (Class A)	Percentage with both recent and of high methodoligal quality estimates
Africa		**67.9%**	**51%**	**83%**	**38%**	**28%**
	East Africa	58.8%	53%	63%	63%	25%
	West and Central Africa	77.2%	52%	92%	31%	31%
	Southern Africa	62.9%	36%	100%	25%	25%
	North Africa	65.6%	67%	75%	25%	25%
America		**87.3%**	**29%**	**60%**	**27%**	**13%**
	North America	100%	60%	67%	67%	33%
	Caribbean	31.3%	8%	0%	0%	0%
	South America	81.9%	50%	71%	29%	14%
	Central America	57.7%	43%	67%	0%	0%
Asia		**95.1%**	**69%**	**76%**	**68%**	**53%**
	Central Asia and Transcaucasia	93.5%	88%	71%	100%	71%
	East and South-East Asia	95.1%	68%	77%	62%	54%
	South-West Asia	100%	100%	67%	100%	67%
	Near and Middle East	42%	46%	83%	17%	17%
	South Asia	100%	83%	80%	80%	60%
Europe		**90%**	**82%**	**71%**	**85%**	**59%**
	Eastern Europe	100%	100%	100%	100%	100%
	South-Eastern Europe	100%	100%	56%	78%	44%
	Western and Central Europe	83%	76%	71%	86%	57%
Oceania		**72.3%**	**9%**	**100%**	**100%**	**100%**
Global		**89.4%**	**52%**	**74%**	**62%**	**45%**

Sources for original estimates on PWID: UNODC annual report questionnaire, progress reports of UNAIDS on the global AIDS response (various years), the former Reference Group to the United Nations on HIV and Injecting Drug Use, peer-reviewed journal articles, study/survey reports and national government reports.

Table: Population coverage, timeliness and methodological quality of information from the 121 countries with data on the prevalence of HIV among people who inject drugs

Region	Subregion	Percentage coverage in terms of number of estimated PWID	Data coverage in terms of countries	Of countries with available estimates: Percentage with recent data (2015 and later)	Percentage with high methodoligcal quality estimes (Class A)	Percentage with both recent and of high methodoligal quality estimates
Africa		**82.9%**	**47%**	**52%**	**85%**	**41%**
	East Africa	87.6%	60%	67%	89%	56%
	West and Central Africa	88.5%	44%	36%	82%	27%
	Southern Africa	59.2%	18%	50%	100%	50%
	North Africa	83.8%	83%	60%	80%	40%
America		**93.6%**	**29%**	**20%**	**60%**	**13%**
	North America	100%	60%	67%	100%	67%
	Caribbean	31.8%	15%	25%	25%	0%
	South America	82.9%	43%	0%	83%	0%
	Central America	32.9%	29%	0%	0%	0%
Asia		**98%**	**80%**	**54%**	**77%**	**44%**
	Central Asia and Transcaucasia	93.5%	88%	86%	100%	86%
	East and South-East Asia	98.7%	79%	53%	67%	33%
	South-West Asia	100%	100%	33%	100%	33%
	Near and Middle East	55.4%	69%	22%	56%	11%
	South Asia	100%	83%	80%	100%	80%
Europe		**100%**	**82%**	**67%**	**55%**	**26%**
	Eastern Europe	100%	100%	100%	75%	75%
	South-Eastern Europe	100%	100%	33%	78%	11%
	Western and Central Europe	99.9%	76%	72%	45%	24%
Oceania		**72.3%**	**9%**	**50%**	**100%**	**50%**
Global		**96%**	**52%**	**55%**	**72%**	**35%**

Sources for original estimates on HIV among PWID: UNODC annual report questionnaire, progress reports of UNAIDS on the global AIDS response (various years), the former Reference Group to the United Nations on HIV and Injecting Drug Use, peer-reviewed journal articles, study/survey reports and national government reports.

Calculation of trends based on qualitative information

In addition to estimates on the extent of drug use, Member States also provide UNODC with qualitative information on their perceptions of drug use trends as well as qualitative information on perceptions of trafficking trends and on perceptions of cultivation trends.

The advantage of the use of such indices based on reported trend indicators is that often larger numbers of countries are able to report such trends, not only developed but also developing countries, thus reducing a potential reporting bias in the results. This is notably of importance when it comes to changes in prevalence rates of drug use as there is a strong bias in favor of household surveys conducted in developed counties. There is also an advantage of using such qualitative information for the analysis of trafficking as the "traditional method", the analysis of trends in quantities seized may reflect not only underlying changes in drug flow but also changes in law enforcement priorities. Finally, for crops where no comprehensive, scientific monitoring of the areas under drug cultivation exist, such as for cannabis, countries report a multitude of indictors that are, in general, not directly comparable with each other (hectares eradicated, plants eradicated, quantities eradicated, plants seized, greenhouses dismantled etc.) and which – when aggregated at the global level - often show into opposite directions. Under such circumstances, the analysis of reported cultivation trends by Member States provides at least some basic indications for the likely overall trends in cultivation.

Thus, in booklet 3, perceptions of cannabis use and cannabis cultivation trends (both for overall cannabis cultivation as well as indoor and outdoor cannabis cultivation) were shown as well as, in booklet 4, perceptions of trends in the trafficking of amphetamine, methamphetamine and ecstasy.

Such trends are typically based on a multitude of indicators, including – in the case of drug use trends - general population prevalence data, school surveys, treatment data, emergency room visits, mortality data, reports by social workers, health care officials and law enforcement officers, arrest data, seizure data, media reports, etc.. Based on this information a simple index has been created. For reports of "large increase" 2 points were allocated, for "some increase" 1 point; for "stable" 0 points; for "some decrease" 1 point was deducted and for "large decrease" 2 points were deducted. The points calculated for each year were subsequently added to the accumulated points of the previous year to arrive at the respective trends perception index. Depending on the indicator used (and thus data availability) the years 2000, 2008 or 2010 were chosen as the starting years of the respective index.

Results of the calculation of the index based on qualitative information of cannabis use at the global level shown below:

Example of calculation of qualitative information on trends in cannabis use at the global level, 2010-2019

	Points	Cannabis use perception trend index

		(2010=0)
2010		0
2011	4	4
2012	9	13
2013	19	32
2014	22	54
2015	15	69
2016	34	103
2017	25	128
2018	35	163
2019	16	179

Points allocated per country:

* "large increase": 2 points; " some increase": 1 point; "stable": 0; "some decrease": -1 point; "large decline": -2 points

Analysis of drug consumption based on the analysis of wastewater is an alternative method to estimate drug consumption

The development of analytical tools and methods for the wastewater analysis took place in recent years in Europe by wastewater research institutes under the umbrella of the COST initiative (Sewage Analysis CORe group Europe under the European Cooperation in Science and Technology initiative), supported by the European Union under the EU Framework Programme Horizon 2020. Both EU and non-EU countries participate in this cooperation.

In order to obtain – as far as possible – comparable data, wastewater in various cities has been analysed by the research institutes participating in the COST exercise over a one-week period each year in spring. The analysis was done for the main cocaine metabolite (benzoylecgonine) as well as for amphetamine, methamphetamine and MDMA.

Such wastewater analyses to determine the extent of drug consumption took place in overall 147 cities across 31 countries in Western, Central and South-Eastern Europe over the period 2011–2020, including in 88 cities in 22 European countries in 2020.[5] The population covered by the sewage systems investigated amounted to 71 million people, equivalent to 12 per cent of the total population in these 31 European countries, ranging from 2 per cent of the total population covered by the wastewater analysis in Romania to 97 per cent in Liechtenstein

[5] UNODC calculations based on wastewater data provided by Sewage Analysis CORe group Europe (SCORE).

with 50 per cent of the 31 European countries showing a population coverage by wastewater analysis from 8 to 28 per cent (interquartile range). Still higher coverage levels were reported by Finland (58 per cent), followed by Iceland (56 per cent) and Denmark (44 per cent).[6]

The approach used is further exemplified for the case of benzoylecgonine, the main cocaine metabolite found in wastewater. The amount of benzoylecgonine found each day in the waste-water was determined and a daily average was calculated. This is important as cocaine use (similar to the use of MDMA or amphetamine) is typically more widespread during the weekend than during normal weak days. In a subsequent step the size of the population responsible for the wastewater in the respective wastewater catchment areas was determined and the results were shown in terms of average milligrams of benzoylecgonine (a main cocaine metabolite) per day found in waste-water per 1000 inhabitants.

The waste-water data used for the analysis in the World Drug Report can be found under:

http://www.emcdda.europa.eu/topics/pods/waste-water-analysis_en

as well as under

https://score-cost.eu/monitoring2016/

http://score-cost.eu/monitoring2017/

http://score-cost.eu/monitoring2018/

https://score-cost.eu/monitoring2019/

and

https://score-cost.eu/monitoring2020/

Even though the results from the analysis of wastewater have been obtained applying high levels of scientific rigour, the subsequent analysis of the trends at the European level has remained a challenge due to the fact that different cities across Europe took part in this exercise in different years over the period 2011–2020 and differences of cocaine consumption across European cities continue to be quite significant. This means that the inclusion or the

[6] UNODC calculations based on wastewater data provided by Sewage Analysis CORe group Europe (SCORE) and United Nations, Department of Economic and Social Affairs, Population Division (2019). *World Population Prospects 2019*, Online Edition. Rev. 1.

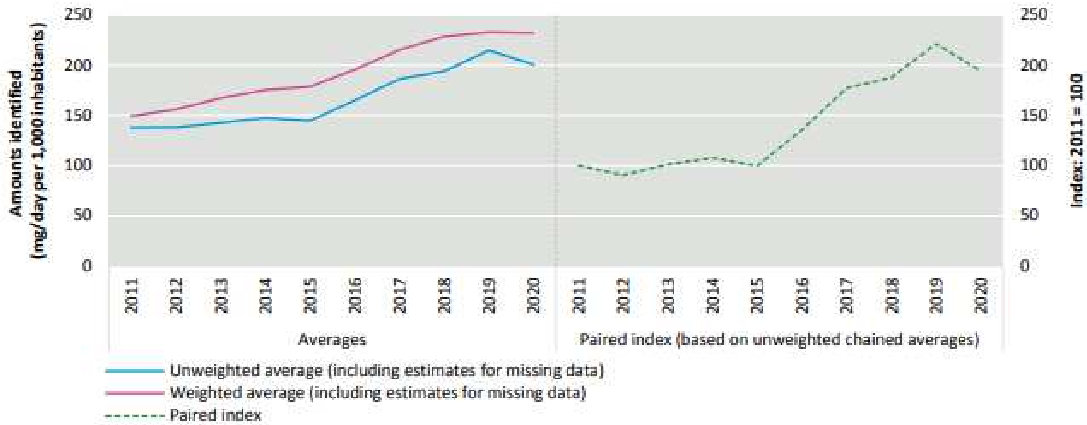
exclusion of a specific city can have a significant impact on the overall average. In other words, calculating and comparing the averages of the cities participating each year in the survey may lead to misleading results as a growing participation of cities with lower levels of cocaine consumption could well offset increases in overall cocaine consumption.

This problem can be overcome by analysing the results of the cities which participated each year in this exercise. However, such results would be based on the results of less than 10 cities and the data from such a limited number of cities are not necessarily a reliable indicator for overall cocaine consumption trends in Europe.

An alternative approach used and shown in the report was to expand the analysis to 147 European cities participating in at least one year in the study analysing bencoylecgonine in wastewater (including 15 cities in 2011, 21 in 2012, 38 in 2013, 52 in 2014, 57 in 2015, 54 in 2016, 66 in 2017, 76 in 2018 and 75 in 2019 and 88 in 2020) as reported to UNODC. UNODC included in its calculations only cities that were geographically located within Europe, i.e. not included were cities though being part of European countries that are located outside of Europe.

Interpolation techniques were used to account for missing data. A broad range of possibilities to deal with missing data exists and is discussed in the literature. The proposed approaches have all merits and shortcomings. This also applies to the interpolation techniques used for this exercise.

Benzoylecgonine (cocaine metabolite) found in wastewater, 147 cities in Europe, 2011–2020



Source: UNODC calculations, based on wastewater data provided by the Sewage Analysis CORe group Europe.

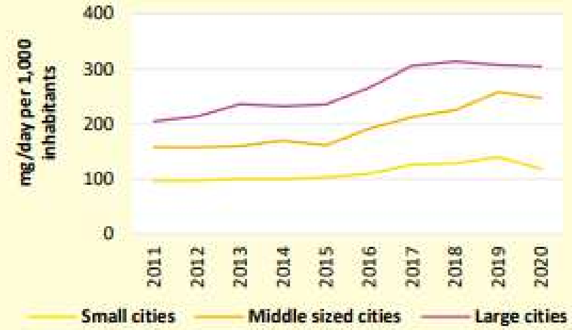
Note: Average quantity of benzoylecgonine found in wastewater in 147 cities, weighted by the population of the sites: assumption of gradual increase or decrease in years in which no analysis took place in a city and there was no change since the latest available data. Owing to the change in the number of cities and sites, the information presented here is not comparable with that presented in the previous editions of the World Drug Report.

First, data from the 147 cities were entered as reported from individual cities. In case of data gaps between years it was assumed that there was a gradual increase or decline in per capita results between the two data points (using the Excel function Series, Trend, Growth). In case of missing data at the beginning or at the end of the data series, the latest reported data (from other years) was used to fill the data gaps. This method helped to reduce the bias due to the reporting of additional cities (or the non-reporting of other cities) in specific years while making better use of reported data, thus reducing potential trend distortions.

In order to calculate a European average, first an **unweighted average** was calculated. Based on this method, cocaine consumption appears to have risen by 56 per cent over the period 2011‒2019 before falling by 7 per cent in 2020 on a year earlier.

A further analysis of such city results by the size of the cities (i.e. the number of people served by the respective sewage system) revealed that hardly any change in 2020 on a year earlier was noted in large cities (with more than 1 million people) while in middle sized cities (100,000 to less than 1 million inhabitants) consumption declined by 4 per cent and in smaller cities (with less than 100,000 inhabitants) cocaine consumption declined by 15 per cent in 2020 on a year earlier, suggesting that cocaine consumption in smaller cities was more affected by the COVID-19 pandemic than in larger cities where hardly any impact was felt.

Benzoylecgonine (cocaine metabolite) found in wastewater in 147 European cities, 2011–2020



Source: UNODC calculations based on wastewater data from the Sewage Analysis CORe group Europe.

Note: Unweighted averages within size-groups of cities. Missing data were imputed with an assumption of a gradual increase/decrease in years in which no analysis took place in a city or latest available data were used.

In any case, the overall net increase - based on an unweighted average – amounted to 45 per cent over the period 2011–2020.

Second, the city results were weighted by the respective population living in the respective waste-water catchment areas. The calculation of an average, weighted by the population living in the various cities (i.e. the population served by the respective sewage system, to be precise) provides a better estimate for the overall cocaine consumption of the population served by the sewage systems of the participating cities. Whether this is, however, a better proxy for overall cocaine consumption among the European population at large is less clear. This would have been the case if all of Europe had participated in this exercise. This was, however, not the case. The overall population of the cities participating in this exercise amounted to 12 per cent of the total population of the European countries participating in this exercise with strong regional differences to be noted (ranging from 2 per cent of the total population covered by the waste-water analysis in one European country to 97 per cent in another). This also reflects the fact that the cities participating in the waste-water exercise were not randomly selected, but are based on a convenience sample of European cities expressing their willingness to participate in this exercise.

Based on this method, the consumption of cocaine in Europe appears to have increased again by 56 per cent over the period 2011–2019 from 143 mg of benzoylecgonine per day found in waste-water per 1,000 inhabitants in 2011 to 233 mg of benzoylecgonine per day found in waste-water per 1,000 inhabitants in 2019 and declining only marginally to 232 mg benzoylecgonine per day in 2020. The overall increase of 56 per cent is – probably - still a conservative estimate for the actual rise as the model assumes no further changes after the latest reported data (i.e. using e.g. 2018 data as a proxy for 2019 and 2020 if no further data were reported after 2018). Thus, the more cities that have not reported in the latest year(s), the flatter will be the resulting curve, potentially under-estimating overall growth and/or in years of decline, under-estimating the net decline.

The method of interpolations used for calculting the weighted averages is shown below based on a hypothetical example of data from four cities:

Hypothetical sample: data of benzoylecgonine per 1000 inhabitants in four cities

	2012	2013	2014	2015	2016	2017	2018	2019	2020
City A	80	78	75	80	92		95	97	100
City B		55	60			85	90		102
City C	150	154			174	180			
City D	140			115	120	125	127	130	135

Interpolation method* used for dealing with missing data for calculating the averages

	2012	2013	2014	2015	2016	2017	2018	2019	2020
City A	80	78	75	80	92	93	95	97	100
City B	55	55	60	67	76	85	90	90	102
City C	150	154	160	167	174	180	180	180	180
City D	140	131	123	115	120	125	127	130	135

*using Excel growth function for filling in data within a time series and assuming no change after latest year available

Reported population living in waste-water catchment areas in cities A, B, C, D

	2012	2013	2014	2015	2016	2017	2018	2019	2020
City A	120,000	125,000	126,000	128,000	130,000				135,000
City B		210,000	215,000			220,000	225,000	225,000	
City C	60,000	65,000			75,000	77,000		80,000	
City D	150,000			170,000	175,000	177,000	180,000	182,000	185,000

Interpolation method* used for estimating population living in waste-water catchment areas in cities A, B, C, D

	2012	2013	2014	2015	2016	2017	2018	2019	2020
City A	120,000	125,000	126,000	128,000	130,000	131,232	132,476	133,732	135,000
City B	210,000	210,000	215,000	216,654	218,321	220,000	225,000	225,000	225,000
City C	60,000	65,000	68,176	71,506	75,000	77,000	77,000	77,000	77,000
City D	150,000	156,391	163,053	170,000	175,000	177,000	180,000	182,000	185,000

*using Excel growth function for filling in data within a time series and assuming no change after latest year available

Based on these data the population weighted averages can be calculated for the four cities. (i.e. for 2020: (100*135,000+102*225000+180*77,000+135*185,000) / sum (135,000, 225,000, 77,000, 185,000) = 121).

The actual calculation was done in Excel, using for each year the "sumproduct" function for benzoylecgonine found in the four cities and the population in the four catchment areas; the resulting total was then divided by the total population in the four waste-water catchment areas in the respective year to arrive at the average for the respective year.

Calculation of average of benzoylecgonine per 1000 inhabitants in four cities

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Average for cities A, B, C, D	**95**	**93**	**93**	**96**	**105**	**111**	**113**	**115**	**121**

Finally, a **chained index** was established which took all city results into account once a city reported data in two subsequent years. i.e. reporting in $year_x$ followed by reporting in $year_{x+1.}$ The advantage of this method is that it is based entirely on reported data and does not require any explicit assumptions to be made about missing data. The disadvantage is that it is based on fewer datapoints as it does not cover trends once there has not been any immediately following reporting. Emerging trends from reporting in $year_{x}$ and again in $year_{x+2}$, or in year $_{x+3}$, etc. are ignored in this model.

The calculated trends for Europe, based on this method, included the analysis of changes in 13 cities over the period 2011–2012 period, 20 cities over the period 2012–2013, 25 cities over the period 2013–2014, 41 cities over the period 2014–2015, 41 cities over the period 2015–2016, 39 cities over the period 2016–2017, 49 cities over the period 2017–2018, 53 cities over the period 2018–2019 and 57 cities over the period 2019–2020. This calculation suggests an overall increase by 121 per cent between 2011 and 2019, and thus far more than found in the calculations based on the assumption of no further changes after the last reporting year, followed by a decline of 12 per cent in 2020 on a year earlier (i.e. a stronger decline than shown in the other model(s)).

Overall cocaine consumption – based on this model - appears to have still almost doubled (rise by 94 per cent) between 2011 and 2020. These results are – probably - on the high-side as there could be a bias in favor of a yearly participation in waste-water analyses among cities where the problem is rapidly growing and there is thus a willingness to fund such an exercise.

A hypothetical sample is shown below, calculating paired averages to arrive at growth rates and combine the results into a chained index:

Hypothetical sample: data of benzoylecgonine per 1000 inhabitants in four cities

	2012	2013	2014	2015	2016	2017	2018	2019	2020
City A	80	78	75	80	92		95	97	100
City B		55	60			85	90		102
City C	150	154			174	180			
City D	140			115	120	125	127	130	135

Hypothetical sample: calculation of growth rates of paired averages

	City A	City B	City C	City D	Averages (of data in reporting and subsequent year)	Growth rates
2012	80		150	140	115.0	
2013	78	55	154		116.0	1.009
2013	78	55	154		66.5	
2014	75	60			67.5	1.015
2014	75	60			75.0	
2015	80			115	80.0	1.067
2015	80			115	97.5	
2016	92		174	120	106.0	1.087
2016	92		174	120	147.0	
2017		85	180	125	152.5	1.037
2017		85	180	125	105.0	
2018	95	90		127	108.5	1.033
2018	95	90		127	111.0	
2019	97			130	113.5	1.023
2019	97			130	113.5	
2020	100	102		135	117.5	1.035

Hypothetical sample: Calculation of chained index

	2012	2013	2014	2015	2016	2017	2018	2019	2020
	100	100*1.009	100.9*1.015	102.4*1.067	109.2*1.087	118.7*1.037	123.2*1.033	127.3*1.023	130.1*1.035
Chained index	100.0	100.9	102.4	109.2	118.7	123.2	127.3	130.1	134.7

While each of the methods used to identify consumption trends has its merits and its shortcomings, it may be still interesting to note that all calculations of benzoylecgonine found in wastewater in Europe resulted in strong increases over the period 2011–2019 (+56 per cent based on the unweighted and the weighted averages and +121 per cent based on the chained index) so that it can be safely stated that cocaine consumption in the European cities investigated rose by more than 50 per cent over the period 2011–2019.

It may be also interesting to note that reported quantities of cocaine seized rose by slightly more than 240 per cent over the period 2011−2019, indicating a strong growth in cocaine trafficking and thus possibly an increase in cocaine consumption over this period. At the same time, data show that despite of undeniable law enforcement successes in recent years – and possibly rising interception rates - , such successes were still not sufficient to effectively counter the rapidly increasing trafficking flow of cocaine from South America to Europe and to stabilize or even reduce overall cocaine consumption in Europe over the period 2011−2019. This seems to have occurred only in 2020 and seems to have been largely linked to the COVID-19 pandemic and the related mobility restrictions across Europe. Drug consumption data – based on the wastewater analysis – showed a stabilization or even some decline in 2020 on a year earlier (-1 per cent based on weighted averages; -4 per cent based on unweighted averages and -15 per cent based on a chained index). While over the period 2018-2019 a clear majority of cities reported increases (37 cities) and only a minority reported declines (15 cities), a stabilization was observed in 2020 with the number of cities reporting an increase (28 cities) equalling the number of cities reporting a decline (28 cities).

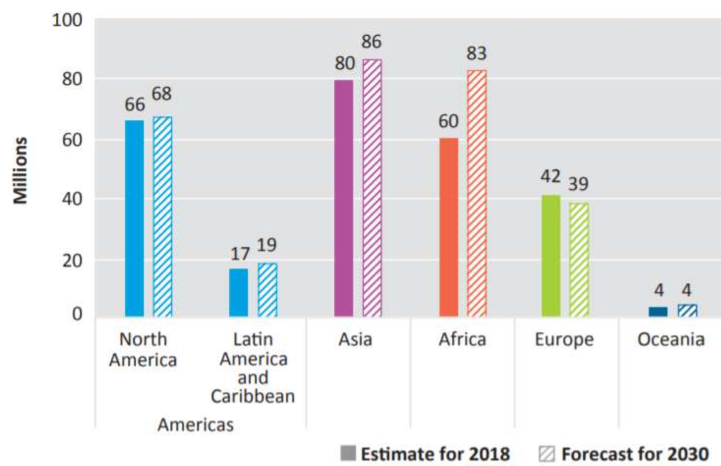
Looking towards 2030: how will demographic changes impact drug use?

This year's World Drug Report looked at forecast of population changes and analysed how these population changes - ceteris paribus - would affect drug use at the global level and in specific regions.

One of the methodological challenges here has been the fact that UNODC publishes each year estimates of drug use by drug and regions while for overall drug use only a global estimate is provided (best estimate of some 269 million people; range: 166 to 373 million people for the year 2018). This estimate is based (i) on the number of cannabis users and the proportion of cannabis users in all drug users (as reported by a number of countries in their national surveys) as well as based (ii) on the aggregate numbers of cannabis, opioids, cocaine, amphetamines and ecstasy users and the proportion of overall drug users in the total of cannabis, opioids, cocaine, amphetamines and ecstasy users from a select number of countries, reflecting the fact that a significant number of drug users consumes more than just one drug.

In order to provide a breakdown of the global number of drug users to estimates at the regional level it was assumed that such a breakdown basically followed the distribution of cannabis users at the global level. Based on these regional estimates for 2018, forecast population growth rates over the period 2018 – 2030 were applied to estimate the likely regional numbers – based on the assumption that current prevalence rates – would not change. Based on these assumptions the overall number of drug users at the global level – merely due to demographic changes – would rise from 269 million in 2018 by some 11 per cent to 299 million by 2030, equivalent to a rise by some 30 million people with most (three quarters) of the increase expected to take place in Africa (23 million people, equivalent to a rise of more than 38 per cent in this region).

Estimated number of people who had used drugs in the past year in 2018 and projected number in 2030, solely as a result of population growth, by region



Source: UNODC estimates, based on responses to the annual report questionnaire; and United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: Revision 2019.*

Note: The 2030 estimates reflect solely the changes in population size by region based on regional projections for the total population aged 15–64 for 2030. They assume no change in drug use; i.e., they assume that the prevalence of drug use in 2018 will remain unchanged by 2030.

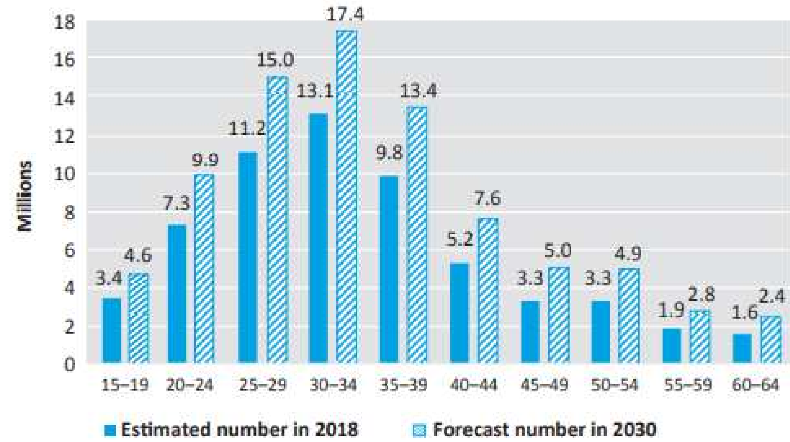
Subsequently, a more detailed analysis of likely changes of drug users by age group due to demographic changes was done for Africa. While detailed forecasts of expected changes in the number of people living in Africa by age group do exist for the period 2018–2030, no actual baseline data of the likely number of drug users by age group in Africa has been published so-far.

A detailed (recent) distribution of cannabis use by age exists, however, for Africa's most populous country, Nigeria,[7] which accounted for 15 per cent of Africa's total population or around a fifth of Africa's total number of cannabis users in 2018. Cannabis was found to be used by 75 percent of all drug users in Nigeria (reflecting an overall annual prevalence rate of drug use of 14.4 per cent and an annual prevalence rate per cent for cannabis use of 10.8 in Nigeria in 2018).[8] For calculation purposes, it was assumed that the distribution of cannabis use in Nigeria by age was a fair reflection of the overall distribution of drug use by age in Nigeria and that this distribution of drug use by age was also a rather good proxy for overall distribution of drug use by age in Africa.

Based on these assumptions the baseline estimates for Africa for the year 2018 could be established, and based on these estimates the likely number of drug users for 2030 could be calculated, based again on the assumption that overall prevalence rates of drug use in the various age cohorts would not change between 2018 and 2030. The estimates suggest increases across all age groups in Africa. The – in absolute numbers – largest increases are to be expected among those aged 30-34 (4.3 million people), followed by those aged 25-29 (3.8 million people) and those aged 35-39 (3.6 million people).

Estimated number of people who had used drugs in the past year in 2018 and projected number in 2030 (solely as a result of projected population growth), by age group, Africa

[7] UNODC, Drug Use in Nigeria 2018 (2019)
[8] *Ibid.*



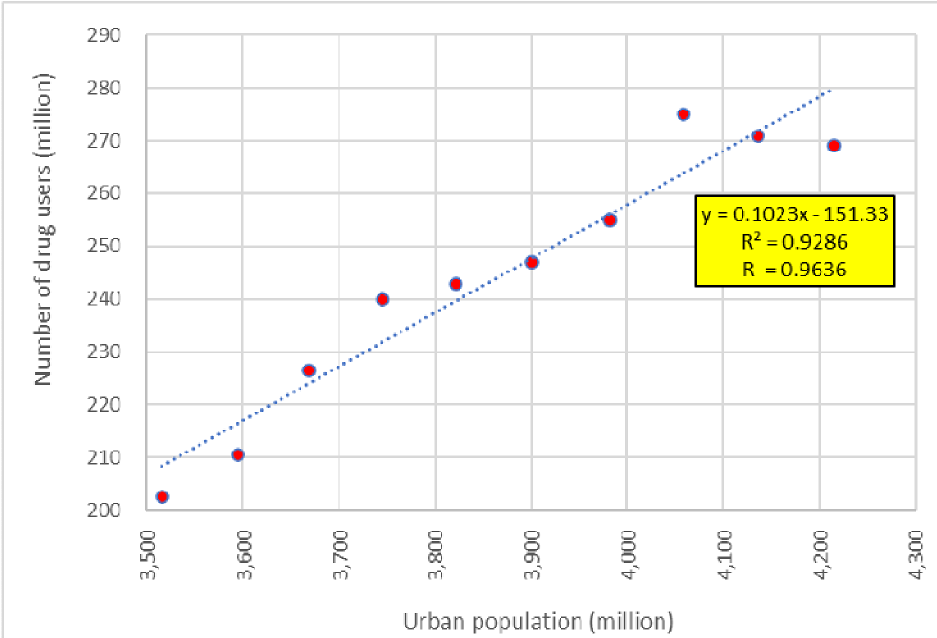
Sources: UNODC estimates, based on responses to the annual report questionnaire; UNODC and Nigeria, *Drug Use in Nigeria 2018* (Vienna, 2019); and United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: Revision 2019.*

Note: The 2030 estimates reflect solely the changes in population size by age, based on the forecast by age of the population aged 15–64 for 2030 in Africa and on the distribution of cannabis use by age in Nigeria in 2018 (used as a proxy in the absence of the distribution of drug use by age for Africa as a whole). They assume no change in drug use; i.e., they assume that the prevalence of drug use in Africa in 2018 will remain unchanged by 2030. They also assume that the relative breakdown by age of drug use (on the basis of the data on cannabis in Nigeria) will remain unchanged over time.

A forecast of no changes in the prevalence rates, resulting – purely based on demographic changes - in some 299 million people expected to use drugs by 2030, however, may still be a conservative estimate.

In fact, booklet 2 showed a strong correlation over the last decade was between changes in the urban population and drug use (R = 0.96 over the period 2009–2018), i.e. the larger the urban population the higher seems to be also the number of drug users at the global level.

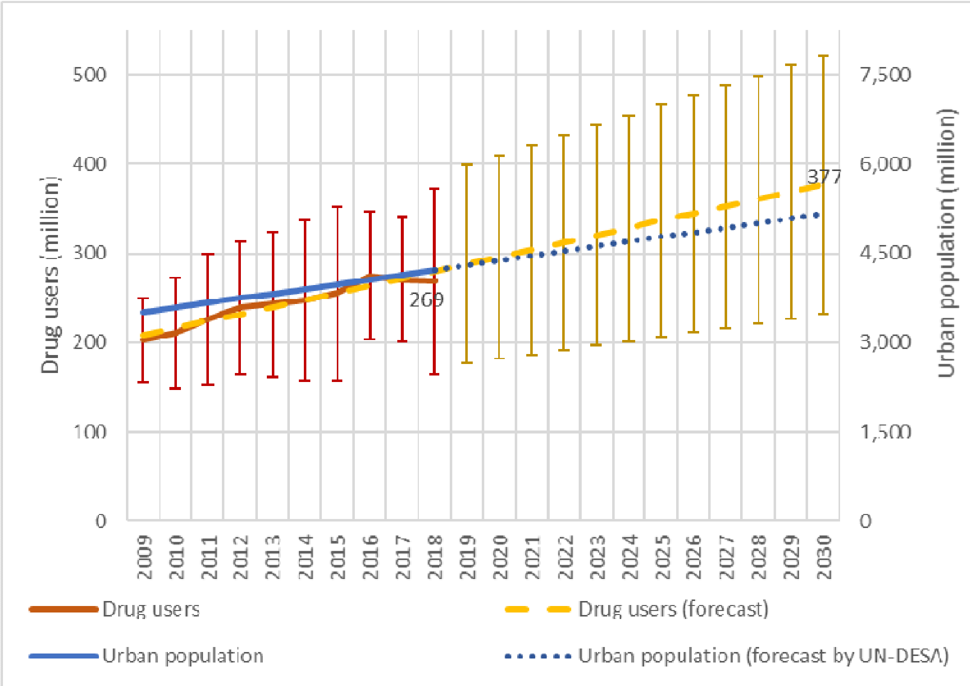
Correlation between urban population and number of drug users, 2009-2018



Source: UNODC calculations based on UNODC, World Drug Report 2020 and UN, Department of Economic and Social Affairs, Population Division, 2018 Revision of World Urbanization Prospects, Urban Population at Mid-Year by Region, Subregion, Country and Area, 1950-2050 (thousands), (New York 2019).

Assuming that such a link has not been a mere statistical artefact but might also hold true in the future, given intrinsic properties of urbanization which favor drug use, a linear regression model to estimate the likely number of drug users by 2030 - based on the relationship between drug users and the urban population over the period 2009-2018 and the forecast number of people expected to live in urban areas at the global level by 2030 (5,167 million people) - would result in an expected growth rate of the total number of drug users by some 40 percent. The overall best estimate would then amount to some 377 million people (i.e. 5,167 * 0.1023 - 151.33; range: 233-523 million people), equivalent to an annual drug use prevalence rate of some 6.8 per cent (range: 4.2-9.5 per cent) by 2030.

Forecast number of drug users by 2030 based on forecast urban population growth



Source: UNODC estimates based on the UNODC, World Drug Report 2020 and UN, Department of Economic and Social Affairs, Population Division, 2018 Revision of World Urbanization Prospects, Urban Population at Mid-Year by Region, Subregion, Country and Area, 1950-2050 (thousands), (New York 2019).

At the same time, it cannot be excluded that the actual number of drug users could turn out to be even higher. In particular, the current move towards cannabis legalization in some countries together with an increasing discussions of such policies in the media may lead to a lowering of risk perceptions regarding cannabis use and may result in an even stronger increase in the use of this drug at the global level over the next decade, notably among females who, in general, tend to be more law abiding than males. Lifting legal restrictions on the use of cannabis may increase, in particular, the use of cannabis by females as well as the overall amounts of cannabis used by both males and females, i.e. showing a stronger increase in the growth rates for daily or near daily use than for annual use. Moreover, significant cuts in drug prevention and drug treatment budgets – possibly a consequence of a lack of financial resources due to the COVID-19 pandemic and the looming economic crisis in several parts of the world – could lead to a further increase in drug use at the global level. At the same time, a large number of factors other than population growth and urbanization can be expected to influence overall changes in drug use. This may include changes in the "youth culture" and "youth trends" (e.g. shifts in the popularity of "rave" or "techno" parties and music festivals, not only in developed but also in developing countries), changes in socio-economic conditions, including changes in income, unemployment and income distribution, changes in the value systems of societies (including changes in the adherence or non-adherence to the rule of law) as well as changes in national and international strategies and programmes and funds made available for drug control on the supply and the demand side as well as changes in drug laws and in their implementation in individual countries.[9]

3. Drug cultivation, production and manufacture

Data on cultivation of opium poppy and coca bush and production of opium and coca leaf for the main producing countries (Afghanistan, Myanmar, Mexico and the Lao People's Democratic Republic, for opium; and Colombia, Peru and the Plurinational State of Bolivia for coca) are mainly derived from national monitoring systems supported by UNODC in the framework of the Global Illicit Crop Monitoring Programme (ICMP). The detailed country reports can be found on the UNODC website https://www.unodc.org/unodc/en/crop-monitoring/index.html

UNODC supported monitoring systems in most other countries started following UNGASS 1998, became operational over the 2000-2002 period and have reported data ever since. Opium cultivation and production estimates are available up to the year 2020.

The preliminary opium poppy cultivation data for 2019, published in last year's World Drug Report 2020 were revised as new information from missing countries became available and some country results were revised. The total area under opium poppy cultivation estimated for the year 2019 thus changed slightly, from 240,800 hectares reported in 2020 World Drug Report, to 236,800 hectares reported in the 2021 World Drug Report for the year 2019. Similarly, estimates for 2011, 2015, 2016 and 2017 slightly decreased whereas the estimate for 2014 increased with the revision in the current 2021 World Drug Report.

Preliminary opium poppy cultivation estimates – 294,350 hectares at the global level for 2020 - should be again interpreted with caution. These estimates are based on new information received from Afghanistan and Myanmar, the two countries responsible for 83

[9] UNODC, World Drug Report 2020, booklets 4 and 5 (New York 2020).

per cent of the global area under poppy cultivation in 2019 or 91 per cent of global opium production in 2019 and on the assumption that the overall area under poppy cultivation in the other countries may not have changed – overall – significantly in 2020 as compared to a year earlier.

No opium poppy survey data for the year 2020 have been received – so-far – from Mexico (accounting for 9 per cent of the global total in 2019), from the Lao PDR (accounting for 2 per cent of the global total) or Colombia (accounting for 0.3 per cent of the global total). The latest opium poppy cultivation data for Mexico for the year 2019, published in the 2021 World Drug Report, cover the opium poppy planting and opium harvesting season from July 2018 – June 2019. They are directly comparable to data published in the World Drug Report for 2018, 2017, 2016 and 2015 but are not directly comparable – for methodological reasons – to data published for 2014 or prior years which have been provided by the US State Department in its annual International Narcotics Control Strategy Report (INCSR).

Opium poppy cultivation in countries which do not conduct area surveys, was estimated with an indirect method (see below). The global opium poppy cultivation estimates for 2020 will be adjusted again in next year's World Drug Report once more data will have become available.

Preliminary estimates suggest that global opium production in 2020 amounted to some 7,410 tons. The preliminary opium production estimates for 2020 are based on data received from Afghanistan and Myanmar and the assumption of no significant changes in the overall total of the other countries.

The preliminary estimate for global opium production in 2019, published in the 2020 World Drug Report got revised slightly from 7,610 tons to 7,620 tons in the World Drug Report 2021 as new data became available.

The preliminary estimates for global opium production in 2020 are with 7,410 tons slightly lower than the global opium production estimates for 2019 and lower than the recent peak reported in 2017 (10,240 tons), though still higher than average annual opium production over the last decade (6,720 tons per year over the period 2010–2019).

It may be also interesting to compare these estimates to earlier estimates though a comparison of opium poppy cultivation and opium production with estimates from previous decades, notably those reported for periods prior to World War II are rendered difficult as the methodologies then used differ from the methodologies used nowadays. Opium production estimates are nowadays mainly derived from an analysis of satellite photos for the analysis of the area under cultivation which is then multiplied with the respective yields of opium per hectare found in specific regions, as derived from detailed yield surveys. In contrast, opium production estimates at the turn of the 19th to the 20th century were mainly derived from a detailed analysis of tax payments and other levies of opium poppy farmers to the authorities.

Such global opium production estimates reported in the proceedings of the Shanghai Opium Commission, 1909, revealed e.g. a global opium production of 41,600 tons of opium for the period 1906/07.[10] For the year 1934 official reports by the League of Nations saw a global opium production of some 16,600 tons [11] falling to 318 tons by 2019 and – based on preliminary estimates by the International Narcotics Control Board (INCB) to 219 tons by 2020.

Comparisons are, however, complicated by the fact that the legal status of opium production was not always clear in the 19th century and the early decades of the 20th century, i.e. data reported usually comprised both legal and illegal production of opium.

Thus, long-term comparisons should be made with estimates for legal and illegal opium production combined.

While the illegal opium production amounted to some 7,410 tons, produced on some 294,350 ha in 2020, the legal production of opium as such amounted to only 219 tons (based on preliminary estimates by the International Narcotics Control Board (INCB) in 2020, produced on some 4,710 ha, down from 318 tons of licit opium produced on some 6,300 ha in 2019.

However, this calculation does not take into account that much of the licit source of morphine production nowadays is in the form of poppy straw rather than in the form of opium as such. The question here is how best to convert such poppy straw data into opium equivalents. One possibility is to calculate the morphine produced out of the poppy straw and to find out how much opium would have been needed to produce such amounts of morphine.

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[10] UNODC, A Century of International Drug Control, 2009), based on data reported by the International Opium Commission (Report of the International Opium Commission, Shanghai, China), Feb. 1909.
[11] UNODC, A Century of International Drug Control, 2009.

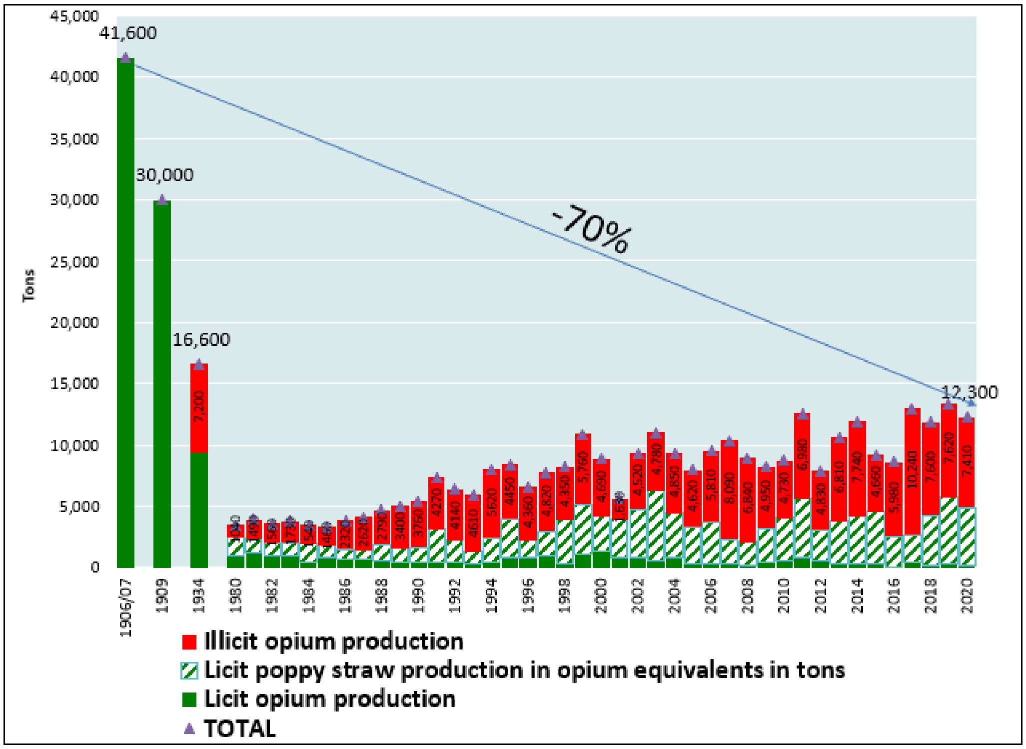
Preliminary estimates suggest that a total of 152,032 ha may have been under (licit) poppy straw cultivation in 2020, i.e. far more than under licit opium cultivation (4,710 ha). Such licit cultivation of together around 156,700 ha compares with an illicit opium cultivation of 294,350 ha. This suggests that the illicit opium poppy cultivation may have accounted for some 65 per cent of the total area under cultivation of opium and poppy straw in 2020.

Data made available by the INCB for 2019 suggested an average ratio of 392 kg of poppy straw per ha under cultivation of poppy straw. Applying such a ratio to the preliminary estimates for 2020 suggests that a total of 59,537 tons of poppy straw to have been produced in 2020 for the extraction of morphine.

Moreover, INCB data show that, the average morphine yield obtained from the poppy straw (directly and/or via AMA (anhydrous morphine alkaloid concentrate of poppy straw) amounted to, on average, 0.83 per cent in 2019 or to 0.71 per cent, on average, over the last ten years (2010-2019). Applying the latter ratio as a proxy for 2020, suggests that some 424 tons of morphine may have been produced. INCB data also show that over the last 10 years (2010-2019), on average, a morphine content of 9.1 per cent was found in the licitly produced opium. In other words, in order to manufacture some 424 tons of morphine – alternatively - around 4,663 tons of opium would have been needed. Thus, opium production in 2020 may have amounted 7,410 tons of illicit opium production, 218 tons licit opium production and 4,663 tons of poppy straw production converted into tons of opium equivalents.

Such licit and illicit opium production estimates for 2020 of some 12,300 tons – though among the highest over the last two decades – are, nonetheless, significantly lower than the opium production estimates reported for the year 1906/07 (41,600 tons of opium) and still less than the licit and illicit opium production estimates reported for the year 1934 (16,600 tons) even though direct comparability remains limited due to changes in the methodologies used.

Global opium production, 1906-2020



Sources: UNODC calculations based on Report of the International Opium Commission, Shanghai, China, Feb. 1909, Vol. II, INCB, *Narcotic Drugs 2020 - Estimated World Requirements for 2021 – Statistics for 2019* (and previous years), UNODC, A Century of International Drug Control (2009), UNODC, *World Drug Report 2021 (and* previous years).

Coca cultivation estimates in the three main Andean coca producing countries were available – at the time of drafting the World Drug Report - up to the year 2019 for Colombia, Peru and the Plurinational State of Bolivia. Results for the year 2020 will be published on UNODC's website as soon as the new reports will have been released.

Estimates of cannabis cultivation in 2009, 2010, 2011 and 2012 in Afghanistan, as well as cannabis cultivation in 2003, 2004 and 2005 in Morocco, were also produced by the UNODC-supported national monitoring systems and can be found on the UNODC website. Estimates for other countries were drawn from ARQ replies and various other sources, including reports from Governments, UNODC field offices and the United States Department of State's Bureau for International Narcotics and Law Enforcement Affairs.

A full technical description of the methods used by UNODC-supported national monitoring systems can be found in the respective national survey reports available at https://www.unodc.org/unodc/en/crop-monitoring/index.html

Net cultivation

Not all the fields on which illicit crops are planted are actually harvested and contribute to drug production. For Afghanistan, a system of monitoring opium poppy eradication is in place which provides all necessary information to calculate the net cultivation area. In Myanmar and the Lao People's Democratic Republic, only the area of opium poppy eradicated before the annual opium survey is taken into account for the estimation of the cultivation area. Not enough information is available to consider eradication carried out after the time of the annual opium survey.

A major difference between coca and other narcotic plants such as opium poppy and cannabis is that the coca bush is a perennial plant which can be harvested several times per year. This longevity of the coca plant should, in principle, make it easier to measure the area under coca cultivation. In reality, the area under coca cultivation is dynamic, making it difficult to determine the exact amount of land under coca cultivation at any specific point in time or within a given year. There are several reasons why coca cultivation is so dynamic, including new plantation, abandonment, reactivation of previously abandoned fields, manual eradication and aerial spraying.[12]

The issue of different area concepts and data sources used to monitor illicit coca bush cultivation was repeatedly investigated by UNODC.[13] To improve the comparability of estimates between countries and years, since 2011 net coca cultivation area at 31 of December is presented not only for Colombia but also for Peru. For technical reasons, the initial area measurement of coca fields takes place on satellite images acquired at different dates of the year and sometimes having different technical specifications. For the Plurinational State of Bolivia, in contrast, most satellite images are taken close to the 31 of December in order to reduce potential errors linked to subsequent eradication. In any case, for

[12] Plant disease and pests are not considered here as their impact is likely to be captured in the coca leaf yield estimates.
[13] See World Drug Report 2011, p. 262.

the Bolivian and Peruvian estimate, these differences are considered to have a limited effect only, whereas the dynamic situation in Colombia requires more adjustments to maintain year-on-year comparability. For more details, please see the country specific reports.

Indirect estimation of illicit opium poppy cultivation

Eradication and plant seizure reports indicate that illicit opium poppy cultivation exists in many countries, which do not regularly conduct illicit crop surveys. Starting 2008 a new methodology was introduced to estimate the extent of this illicit cultivation with an indirect method based on two indicators available in UNODC's databases: eradicated poppy area and opium poppy (plant, capsule) seizures reported as units or weight.

Prioritization of data sources: Whenever possible, the eradicated poppy area was used as this indicator is conceptually closest. If this indicator was not available, poppy plant seizure data was used, which requires an additional conversion of the seized amount into area eradicated. It can be assumed that plant seizures are often a different way of recording eradication. e.g. in cases where area measurements are technically difficult or because the law requires all seized material to be weighed even if the seizure consists actually of eradicated plants on a field. Large-scale or long-distance illicit trade with opium poppy plants is unlikely as the plants are bulky, perishable and of low value.

Eradication factor: Evidence from countries which provide both illicit cultivation and eradication data indicates that illicit cultivation is typically a multiple of the area eradicated. This relationship, averaged over the last five years for which information is available, was used to calculate a factor which allowed to estimate illicit cultivation in countries from eradication figures. Since 2008, this factor is based on opium poppy cultivation and eradication data from Colombia, Lao People's Republic, Mexico, Myanmar, Pakistan, Thailand and Guatemala. Over the years, the average over these five countries ranged between 2.1 and 3.0 (eradicated area * factor = net cultivation area). (Afghanistan was not considered for the calculation of the factor as the objective was to estimate low to mid-levels of illicit cultivation. Afghanistan, representing two thirds or more of global illicit poppy cultivation, clearly fell outside this range).

Plant seizures: seizures of poppy plant material usually happen close to the source, i.e. in vicinity of the cultivated area. The data available to UNODC does not allow to accurately and systematically differentiate between the various parts (capsules, bulbs, entire plants) of the plant seized as for plant seizures. Most (roots, stem, leaves, capsules) or only some parts (poppy straw, capsules only) of the plant may be seized. While this does not influence seizure data given in plant units, it plays a role when interpreting seizure data given as weight

Plant seizure data in units represent plant numbers, which can be converted into area (ha) using an average number of opium poppy plants per hectare. Yield measurements from Afghanistan and Myanmar, where UNODC has conducted yield surveys over several years, indicate an average figure of about 190,000 plants per hectare. Dividing poppy plant seizure numbers by this factor results in estimate of the area on which the seized material was cultivated. This is equivalent to eradicated area, as the seized material was taken out of the production cycle. Eradicated area multiplied with the eradication factor described above yields then cultivation area.

Plant seizure data reported as weight: In order to convert the weight of seized poppy plants into area, a typical biomass per hectare of poppy was estimated based on the evaluation of various sources. The biomass yield in oven-dry equivalent including stem, leaves, capsule and seeds reported by a commercial licit opium poppy grower in Spain[14] was 2,800 kg/ha for rain-fed and 7,800 kg/ha for irrigated fields respectively. Information on the weight of roots was not available. Loewe[15] found biomass yields between 3,921 kg/ha to 5,438 kg/ha in trial cultivation under greenhouse conditions. Acock et al.[16] found oven-dry plant weights of about 37 grams including roots in trials under controlled conditions corresponding to a biomass yield of around 7,000 kg/ha with the assumed plant density of 190,000/ha. Among the available biomass measurements only the figures from Spain referred to poppy grown under field conditions. All other results fell into the range between the non-irrigated and irrigated biomass yields (2,800 – 7,800 kg/ha) reported. For purposes of this calculation the simple average of these two values was taken.

[14] Personal communication, 2010, from Alcaliber company.
[15] Personal communication, 2010, see also Loewe, A. (2010). Remote Sensing based Monitoring of Opium Cultivation in Afghanistan. Philosophische Fakultaet. Bonn, Rheinische Friedrich-Wilhelms-Universitaet**:** 106.
[16] Acock, M. C., R. C. Pausch, et al. (1997). "Growth and development of opium poppy (Papaver Somniferum L.) as a function of temperature." Biotronics **26**: 47-57.

Two caveats have to be made: a) As the reporting format does not differentiate between capsules and plants or between the different growth stages of a poppy plant, it was assumed that the reported weight refers to whole, mature plants. This leads to a conservative estimate as many plant seizures are actually carried out on fields before the poppy plants reach maturity. b) The reference biomass measurements from scientific studies are expressed in oven-dried equivalents, whereas the reported weights could refer to fresh weight or air-dry weight; both of which are higher than the oven-dry equivalent weight equivalent. This would lead to an over-estimation of the illicit cultivation area. In the case of young plants, which are typically fresh but not yet fully grown, both errors could balance off, whereas in the case of mature or harvested plants, which tend to be drier, both errors would be smaller.

In order to avoid the fluctuations typically present in seizure and eradication data, the above calculations were based on plant seizures averaged over the most recent five-year period, rather than datapoints relative to the specific year. If no eradication or plant seizure was reported in that period, no value was calculated.

Yield[17] and production

To estimate potential production of opium, coca leaf and cannabis (herb and resin), the number of harvests per year and the total yield of primary plant material has to be established. The UNODC-supported national surveys take measurements in the field and conduct interviews with farmers, using results from both to produce the final data on yield.

Opium yield surveys are complex. Harvesting opium with the traditional lancing method can take up to two weeks as the opium latex that oozes out of the poppy capsule has to dry before harvesters can scrape it off and several lancings take place until the plant has dried. To avoid this lengthy process, yield surveyors measure the number of poppy capsules and their size in sample plots. Using a scientifically developed formula, the measured poppy capsule volume indicates how much opium gum each plant potentially yields. Thus, the per hectare opium yield can be estimated. Different formulas were developed for South-East and South-West Asia. In Afghanistan, yield surveys are carried out annually; in Myanmar regularly.

[17] Further information on the methodology of opium and coca leaf yield surveys conducted by UNODC can be found in United Nations (2001): *Guidelines for Yield Assessment of Opium Gum and Coca Leaf from Brief Field Visits*, New York (ST/NAR/33).

For coca bush, the number of harvests varies, as does the yield per harvest. In the Plurinational State of Bolivia and Peru, UNODC supports monitoring systems that conduct coca leaf yield surveys in several regions, by harvesting sample plots of coca fields over the course of a year, at points in time indicated by the coca farmer. In these two countries, yield surveys are carried out only occasionally, due to the difficult security situation in many coca regions and because of funding constraints. In Colombia, coca leaf yield estimates are updated yearly through a rotational monitoring system introduced in 2005 that ensures that every yield region is revisited about every three years. However, as the security situation does not allow for surveyors to return to the sample fields, only one harvest is measured, and the others are estimated based on information from the farmer. In 2013 for the first time the concept of productive area was applied to calculate the coca leaf yields in Colombia, taking into account the dynamics of the fields due to spraying and eradication for which some fields are only partly productive during the year. This new way of calculating was retroactively applied to the results of 2005-2012, giving slightly different results than published before [18]. In Peru and the Plurinational State of Bolivia the additional production of partly productive areas is not considered for the coca leaf yield estimates.[19]

Conversion factors

The primary plant material harvested - opium in the form of gum or latex from opium poppy, coca leaves from coca bush, and the cannabis plant - undergo a sequence of extraction and transformation processes, some of which are done by farmers onsite, others by traffickers in clandestine laboratories. Some of these processes involve precursor chemicals and may be done by different people in different places under a variety of conditions, which are not always known. In the case of opium gum, for example, traffickers extract the morphine contained in the gum in one process, transform the morphine into heroin base in a second process, and finally produce heroin hydrochloride. In the case of cocaine, coca paste is produced from either sun-dried (in the Plurinational State of Bolivia and Peru) or fresh coca leaves (in Colombia), which is later transformed into cocaine base, from where cocaine hydrochloride is produced.

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[18] More information on the results of the methodology used can be found in the report on coca cultivation in Colombia for 2013 (UNODC/ Government of Colombia, June 2014) available on the internet at http://www.unodc.org/unodc/en/crop-monitoring/index.html.

[19] In 2013 a correction factor was applied for the time that fields in Peru were productive during the year, however this approach was abolished as of 2014 due to incomplete eradication data. More information about the 2013 calculation to be found at page 73 of the Peru coca cultivation survey report for 2013 available on the internet at http://www.unodc.org/unodc/en/crop-monitoring/index.html.

The results of each step, for example from coca leaf to coca paste, can be estimated with a conversion factor. Such conversion factors are based on interviews with the people involved in the process, such as farmers in Colombia, who report how much coca leaf they need to produce 1 kg of coca paste or cocaine base. Tests have also been conducted where so-called 'cooks' or 'chemists' demonstrate how they do the processing under local conditions. A number of studies conducted by enforcement agencies in the main drug-producing countries have provided the orders of magnitude for the transformation from the raw material to the end product. This information is usually based on just a few case studies, however, which are not necessarily representative of the entire production process. Farmer interviews are not always possible due to the sensitivity of the topic, especially if the processing is done by specialists and not by the farmers themselves. Establishing conversion ratios is complicated by the fact that traffickers may not know the quality of the raw material and chemicals they use, which may vary considerably; they may have to use a range of chemicals for the same purpose depending, on their availability and costs; and the conditions under which the processing takes place (temperature, humidity, et cetera) differ.

It is important to take into account the fact that the margins of error of these conversion ratios – used to calculate the potential cocaine production from coca leaf or the heroin production from opium - are not known. To be precise, these calculations would require detailed information on the morphine content of opium or the cocaine content of the coca leaf, as well as detailed information on the efficiency of clandestine laboratories. Such information is limited. This also applies to the question of the psychoactive content of the narcotic plants.

UNODC, in cooperation with Member States, continues to review coca leaf to cocaine conversion ratios as well as coca leaf yields and net productive area estimates.[20] More research, however, is needed to establish comparable data for all components of the cocaine production estimate.

Many cannabis farmers in Afghanistan and Morocco conduct the first processing steps themselves, either by removing the upper leaves and flowers of the plant to produce cannabis herb or by threshing and sieving the plant material to extract the cannabis resin. The herb and resin yield per hectare can be obtained by multiplying the plant material yield with an extraction factor. The complex area of cannabis resin yield in Afghanistan was investigated in

[20] More detailed information on the ongoing review of conversion factors was presented in the 2010 *World Drug Report*, p.251 ff.

2009, 2010, 2011 and 2012. The yield study included observation of the actual production of resin, which is a process of threshing and sieving the dried cannabis plants. In Morocco, this factor was established by using information from farmers on the methods used and on results from scientific laboratories. Information on the yield was obtained from interviews with cannabis farmers.[21] Given the high level of uncertainty and the continuing lack of information for the large majority of cannabis-cultivating countries, the estimates of global cannabis herb and resin production have not been calculated.

"Potential" production versus "actual production"

'Potential' heroin or cocaine production refers to total production of heroin or cocaine if all the cultivated opium or coca leaf, less the opium and coca leaf consumed as such, were transformed into the end products in the respective producer country in the same year. Direct consumption of opium or the coca leafis being taken into account. Thus, for example, consumption of coca leaf considered licit in the Plurinational State of Bolivia and Peru is deducted from the amounts of coca available for the transformation into cocaine.. Similarly, opium consumed in Afghanistan and neighbouring countries is deducted from the amounts of opium available for heroin production.

In contrast, opium stocked or opium used from stocks accumulated over previous years is not considered in the calculation of 'potential' heroin manufacture though it may have a significant impact on 'actual' heroin manufacture. Similarly, none of the coca leaf harvested in a previous year is taken into consideration when it comes to the manufacture of cocaine. This is less of a problem for the coca leaf, but it should be noted that opium can be stored for extended periods of time and converted into intermediate or final products long after the harvest year. Thus 'actual' heroin manufacture, making use of accumulated stocks of opium from previous years, can thus deviate significantly from 'potential' heroin manufacture out of the opium produced in a specific year.

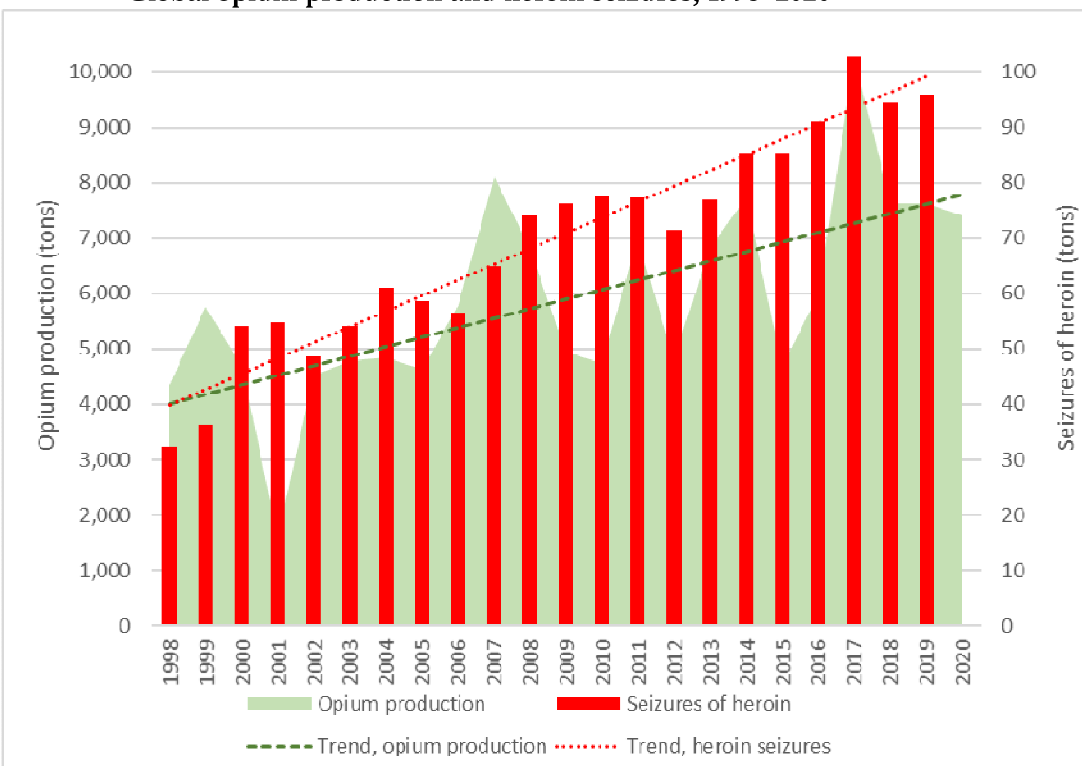
While global opium production shows strong year-on-year fluctuations (standard deviation of percentage changes on a year earlier: 0.5 over period 1998-2019), global heroin seizures tend to remain rather smooth (standard deviation of percentage changes on a year earlier: 0.12

[21] For greater detail on studies with cannabis farmers, see: UNODC, *Enquête sur le cannabis au Maroc 2005*, Vienna, 2007.

over period 1998-2019). This suggests that there may be – irrespective of a long-term upward trend – a rather constant year-on-year output in the manufacture of heroin as 'actual' global heroin manufacture, in contrast to global opium production, tends to be rather smooth.

Thus, average numbers of such calculated 'potential' heroin manufacture over a few years (e.g. over a period of 5 years) may turn out to be a more realistic estimate of the actual amounts of heroin manufacture in a specific year than the calculated 'potential' heroin manufacturing estimate for that year.

Global opium production and heroin seizures, 1998–2020



Sources: UNODC, opium surveys; UNODC, responses to the annual report questionnaire; and other Government sources.

This is of significance in years when opium production was either rather high or rather low as compared to other years. Thus, for 2017, the peak year in global illicit opium production, the potentially manufactured amounts of heroin amounted to between 677 and 1,027 tons with a mid-point estimate of 852 tons. Such estimates, however, are unlikely to have been close to actual quantities of heroin manufactured in that year, deviating by more than 60 per cent from the previous five-years average (528 tons per year over the period 2013-2017).

Such an increase in 2017 – if correct – should have been also reflected in other indicators. However, this has not been the case. Heroin prices did not colapse and heroin purity did not massively increase. Global heroin seizures in 2017 (102.7 tons) were just 16 per cent higher than the previous five-years average (88.2 tons per year over the period 2013-2017) and a year later (with 94.5 tons of heroin seized) only 3 per cent higher than the previous five-years average (91.8 tons per year over the period 2014-2018).

The differences are far less pronounced in years when opium production has been close to average. For the year 2020, e.g., global opium production amounted to 7,410 tons, which was slightly higher than a year earlier though 5 per cent below the previous five−years average while the calculated potential quantities of globally manufactured heroin amounted to between 454 and 694 tons with a mid-point estimate of 574 tons. This compares with a five-years average of the potential quantities of globally manufactured heroin of 597 tons, equivalent to a difference of 4 per cent from the mid-point estimate for 2020. The two estimates were thus almost identical.

At the same time, it should be noted that coca leaf seizures and opium seizures are not taken into account in the calculation of potential global cocaine and global heroin manufacture. In particular, this tends to over-estimate the actual amount of opium available for the manufacture of heroin as opium seized is no longer available for the manufacture of heroin. For 2020, eestimated global opium production would have been sufficient to potentially manufacture 454–694 tons of heroin (expressed in export purities). As discussed above, an estimate of potential manufacture of heroin does not take into account previous years' opium being used for the manufacture of heroin or the stockpiling or clearance of stocks of opium in a specific year. Given rather stable opium production levels over the period 2018–2020, such changes in stocks, however, are unlikely to have affected – to any significant extent – heroin manufacture in 2020. In this respect, estimated potential manufacture of heroin seems to have been a rather good proxy for actual manufacture of heroin in 2020. Still, seizures of opium reduced the overall opium available for the manufacture of heroin. Using the 2019 opium seizure data as a proxy for the seizures in 2020 (which have not been available at the time of writing this report) actual global manufacture of heroin may have ranged from 405–612 tons (at export purities) in 2020, i.e. actual manufacture of heroin in 2020 may have been some 11 per cent lower than the calculated potential manufacture estimate of heroin.

Purity of potential production estimates

For **cocaine**, potential production of 100 per cent pure cocaine is estimated. In reality, clandestine laboratories do not produce 100 per cent pure cocaine but cocaine of lower purity which is often referred to as 'export quality'.

For **heroin**, two conversion ratios are used. Apart from Afghanistan, not enough information is available to estimate the production of heroin at 100 per cent purity. Instead, potential production of export quality heroin is estimated, whose exact purity is not known and may vary. For Afghanistan, the calculations are more detailed. Here the share of all opium converted to heroin is estimated and a specific conversion ratio is applied, which uses an estimated purity for heroin of export quality, derived from wholesale purities found in other countries in the neighbourhood.

Although it is based on current knowledge on the alkaloid content of narcotic plants and the efficiency of clandestine laboratories, it should be noted that 'potential production' remains a hypothetical concept and is not an estimate of actual heroin or cocaine production at the country or global level.

The concept of potential production is also different from the theoretical maximum amount of drug that could be produced if all alkaloids were extracted from opium and coca leaf. The difference between the theoretical maximum and the potential production is expressed by the so-called laboratory efficiency, which describes which proportion of alkaloids present in plant material clandestine laboratories are actually able to extract.

Country-specific estimates

Colombia

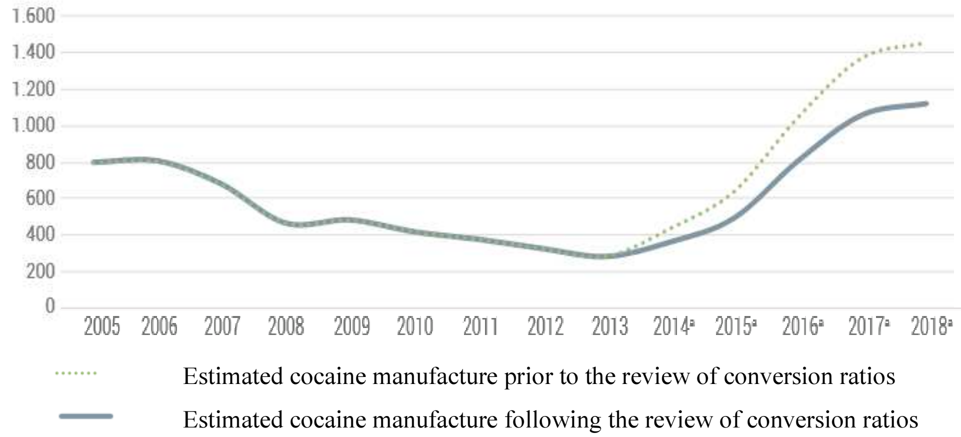
From 2013 onwards, the yearly productive areas were estimated, instead of using the average area under coca cultivation of the reporting year and the previous year (the approach used in previous reports). In addition, a different conversion factor for estimating cocaine base was applied. Both the adjustment of the productive area estimate and the estimation of the conversion factor for cocaine base were retroactively applied to the results of 2006-2012.[22]

In 2019, the overall conversion ratios from coca leaf production to the manufacture of cocaine hydrochloride in Colombia were reviewed and the results of this review were retroactively applied to the results from Colombia for the years 2014 to 2018. This review became necessary as due to changes in the overall political context of the country, farmers – often without in-depth knowledge of chemistry – got increasingly involved in the manufacture of coca paste and cocaine base, resulting in overall efficiency losses. At the same time, several of the larger cocaine manufacturing facilities operated by professional chemists showed efficiency gains.

The net result was still a loss in the overall efficiency as compared to a decade ago (and thus a downward revision of cocaine manufacturing estimates for Colombia over the period 2014-2018), going hand in hand with rising levels of efficiency in the manufacturing of cocaine identified over the period 2014-2019.

[22] More information on the results of the two approaches and the methodology used can be found in annex 3 of the report on coca cultivation in Colombia for 2013 (UNODC/ Government of Colombia, June 2014) available on the internet at http://www.unodc.org/unodc/en/crop-monitoring/index.html and in UNODC and Gobierno de Colombia, *Colombia, Monitoreo de territorios afectados por cultivos ilícitos 2015*, July 2016, available on the internet at: https://www.unodc.org/documents/crop-monitoring/Colombia/Monitoreo_Cultivos_ilicitos_2015.pdf.

Estimates of cocaine hydrochloride manufacture in Colombia (tons), 2005-2018



Source: UNODC and Gobierno de Colombia, Monitoreo de territorios afectados por cultivos ilícitos 2018 (August 2019).

[a] Years to which the revised conversion ratios were applied.

Peru

Potential cocaine production in Peru is estimated from potential coca leaf production and after deducting the amount of coca leaf estimated to be used for traditional purposes according to Government sources (9,000 mt of sun-dry coca leaf).

The Plurinational State of Bolivia

Potential cocaine production in the Plurinational State of Bolivia is estimated from potential coca leaf production after deducting the amount of coca leaf produced on 12,000 ha in the Yungas of La Paz where coca cultivation has been for years authorized under national law.

"Old" versus "new" conversion ratios for cocaine

Cocaine estimates based on the "old" and the " new" conversion ratios are shown. Results based on the "old" conversion ratios are shown for the years in which no estimates based on the "new" conversion ratios have been available. Only for a short period, 2005–2009, estimates based on both the "old" and the "new" conversion ratios are shown, indicating an overall higher level though similar trends for the cocaine estimates based on the “new” conversion ratios.

In order to estimate cocaine production from the area under coca cultivation, the coca leaf yield per region is estimated based on yield studies as well as – based on experiments in the field - the coca-leaf to coca-paste conversion, the coca-paste to cocaine base conversion and the cocaine-base to cocaine hydrochloride conversion. The results are then adjusted to show an overall conversion ratio from coca leaf to (a potential) 100 per cent pure cocaine hydrochloride.

The ‘old’ conversion ratios from coca leaf to cocaine hydrochloride are based on studies conducted by the United States Drug Enforcement Administration (DEA) in the Andean region in the 1990s. The ratios for Colombia – in close cooperation with the Colombian authorities - were updated in 2004 and are part of the ‘old’ conversion ratio series.

In subsequent years the DEA undertook new studies in Peru (2005) and in the Plurinational State of Bolivia (2007-2008), following indications that the laboratory efficiency in these countries may have improved.

The ‘new’ conversion rates used in this report – for the years 2007-2019 – however, have not been reconfirmed so far in national studies as funds for such studies have not been forthcoming. For this reason, cocaine production data are not shown separately for Peru and the Plurinational State of Bolivia; only the global total based on the ”new” conversion ratio is shown. The calculations of cocaine production based on the “new” conversion ratios refer to the “new” coca leaf to cocaine hydrochloride transformation ratios found by the DEA for Colombia, Peru and the Plurinational State of Bolivia and the updated ratios for Colombia. It should be noted though that the ”new” conversion ratios are still temporary; they will be updated as soon as new data, jointly established between the respective Member States and UNODC will become available (for more details, see World Drug Report 2010 (United Nations publication, Sales No. E.10.XI.13, pp. 251 and 252).

4. Drug trafficking

Seizures

The analysis presented in this report is mainly derived from the ARQ responses from Member States up to the 2019 reporting year. Seizures are reported in volume terms ("quantities seized") as well as in terms of the number of seizure cases.

Including information from other sources, UNODC was able to obtain data on quantities of drugs seized from 126 countries and territories for 2019 Over the 2015–2019 period seizures from in total 154 countries and territories were obtained, covering 94 per cent of the world's total population. Seizures are thus the most comprehensive indicator of the drug situation and its evolution at the global level. Although seizures may not always reflect trafficking trends correctly at the national level, they tend to show reasonable representations of trends at the regional and global levels.

The analysis of seizure cases enables a direct comparison of data across drug categories. Reporting of seizure cases is, however, less comprehensive. A total of 66 countries and territories reported seizure cases to UNODC in 2019, or 102 countries and territories over the 2015–2019period, representing 80 per cent of the world's total population.

Countries reporting seizures of drugs in volume terms may report seizures using a variety of units, primarily by weight (kg) but also in litres, tablets, doses, blotters, capsules, ampoules, et cetera. When reporting about individual countries in individual years, UNODC endeavours to be as faithful as possible to the reports received, but often it is necessary to aggregate data of different types for the purposes of comparison. For the aggregation, conversion factors are used to convert the quantities into 'kilogram equivalents' (or 'ton equivalents'). UNODC continues to record and report the disaggregated raw data, which are available in the seizure listings published at: World Drug Report 2021_Annex (unodc.org) under 7.1 Drug seizures 2015–2019.In these tables, seizure quantities are reproduced as reported. In the rest of the Report, seizure data are often aggregated and transformed into a a unique unit of measurement (such as "kilogram equivalents" or "ton equivalents"). Moreover, at some points in the analysis, purity adjustments are made where relevant and where the availability of data allows.

The conversion factors affect seizure totals of amphetamine-type stimulants (ATS), as a significant share of seizures of these drug types is reported in terms of the number of tablets. Apart from seizures of ATS tablets, drug seizures are mainly reported to UNODC by weight, and sometimes by volume. This includes seizures of ATS which are not seized in tablet form (for example, ATS in powder, crystalline or liquid form) as well as seizures of other drug types, such as heroin and cocaine. Moreover, ATS seizures made in tablet form are also sometimes reported by weight, and in some cases, the reported total aggregated weight possibly includes ATS seized in different forms. Reports of seizures by weight usually refer to the bulk weight of seizures, including adulterants and diluents, rather than the amount of controlled substance only. Moreover, given the availability of data, accurate purity adjustments for bulk seizure totals in individual countries are feasible in only a minority of cases, as they would require information on purity on a case by case basis or statistically calibrated data, such as a weighted average or a distribution. The bulk weight of tablets is easier to obtain and less variable.

To ensure the comparability of seizure totals across different years and countries, UNODC uses conversion factors for ATS tablets intended to reflect the bulk weight of the tablets rather than the amount of controlled substance. The factors used in this edition of the *World Drug Report* are based on available forensic studies and range between 90 mg and 300 mg, depending on the region and the drug type, and also apply to other units which are presumed to represent a single consumption unit (dose). The table below lists the factors used for ATS, by type and region. The conversion factors remain subject to revision as the information available to UNODC improves.

Weight of tablets in milligrams

	Ecstasy (MDMA or analogue)	Amphetamine	Methamphetamine	Prescription stimulants	Other stimulants	Non-specified amphetamines
Africa	271	250	250	250	250	250
Asia (excluding Near and Middle East/ South-West Asia)	300	250	90	250	250	250
Europe	271	253	225	250	250	250
Central and South America and Caribbean	271	250	250	250	250	250
Near and Middle East/ South-West Asia	237	170	250	250	250	250
North America	250	250	250	250	250	250
Oceania	276	250	250	250	250	250

For the other drug types, the weight of a 'typical consumption unit' was assumed to be: for cannabis herb, 500 mg; for cannabis resin, 135 mg; cocaine and morphine, 100 mg; heroin, 30 mg; LSD, 0.05 mg (50 micrograms); and opium, 300 mg. For opiate seizures (unless specified differently in the text), it was assumed that 10 kg of opium were equivalent to 1 kg of morphine or heroin. As in previous editions of the World Drug Report, seizures quantified by volume (litres) are aggregated using a conversion ratio of 1 kilogram per litre, which applies to all drug types. Cannabis plants are assumed to have an average weight of 100 grams.

Though these transformation ratios can be disputed, they provide a means of combining the different seizure reports into one comprehensive measure. The transformation ratios have been derived from those normally used by law enforcement agencies, in the scientific literature and by the International Narcotics Control Board, and were established in consultation with UNODC's Laboratory and Scientific Section.

Moreover, total seizures of 148 tons of codeine, 60 tons of tramadol, 13 tons of fentanyl and 7 tons of other pharmaceutical opioids were reported for 2019. Such seizure figures, however, may be misleading as doses across pharmaceutical opioids vary significantly.

Directly comparable doses are, however, difficult to identify. One of the most comprehensive data set in this regard are the defined daily doses for statistical purposes (S-DDD), established – with the help of experts - by the INCB. For the transformation of seizures of pharmaceutical opioids into doses such S-DDD, shown in milligrams of various substances per day, were used:

Substance	S-DDD in mg
Acetyldihydrocodeine	40
Alphaprodine	120
Anileridine	65
Bezitramide	15
Codeine (analgesic)	240
Codeine (cough suppressant)	100
Dextromoramide	20
Dextropropoxyphene hydrochloride	200
Dextropropoxyphene napsylate	300
Difenoxin	3
Dihydrocodeine (analgesic)	150
Dihydrocodeine (cough suppressant)	100
Diphenoxylate	15
Dipipanone	75
Ethylmorphine	50
Fentanyl	0.6
Heroin	30
Hydrocodone	15
Hydromorphone	20
Ketobemidone	50
Levorphanol	6
Methadone	25
Morphine	100
Nicomorphine	30
Normethadone	10
Norpipanone	18
Opium	100
Oxycodone	75
Oxymorphone	10
Pethidine	400
Phenazocine	20
Phenoperidine	4
Pholcodine	50
Piminodine	100
Piritramide	45
Propiram	100
Thebacon	15
Tilidine	200
Trimeperidine	200

Source: INCB, Narcotic Drugs 2019 (New York 2020).

For buprenorphine, a S-DDD of 8 mg - as reported by the INCB in its annual report on Psychotgropic Substances[23] - was used.

No such conversion ratios, however, have been established by the INCB for tramadol as this substance is not under international control. In this case, a review of doses provided in the literature ranged from 50 to 400 mg per day with a median of around 250 mg per day. (Tramadol tablets typically contain between 50 and 250 mg, i.e. the median daily dose would be equivalent to between 1 and 5 tablets, depending on the strength of the tablet). This ratio can be used as the best estimate for converting reported seizures into daily doses of seized drugs.

Moreover, reports suggest that most of the codeine seized 2019 was South Asia in the form of cough syrup while most of the fentanyl was seized in the United States and was heavily diluted.

Expressed in kilogram equivalents (applying the conversion ratios mentioned above) and taking into account that most of the codeine was seized as cough syrup and that average purity of fentanyl found on the black market in the United States amounted to just 9 per cent in 2019, calculations suggest that 39 per cent of the seized "pharmaceutical opioids", were accounted for by fentanyl, rising to 52 per cent if all of the different fentanyl mixtures and analogues are included. The next "most prominent" pharmaceutical opioids in terms of quantities seized, purity adjusted and transformed into S-DDS, were codeine (19 per cent of the total), followed by tramadol (16 per cent) and methadone (4 per cent).

Distribution of global seizures of pharmaceutical opioids, 2019

	Seizures in kg equivalents	Distribution (based on seizures in kg equivalents)	Typical "purity" of substances seized	Purity adjusted seizures	S-DDDs ratios (incl. estimates for non-defined substances)	Purity adjusted seizures in S-DDDs	Distribution (based on purity adjusted seizures in S-DDDs)
Codeine	147,552.99	65%	20%	29,510.60	100	295,105,974	19.3%
Tramadol	60,174.75	26%	100%	60,174.75	250	240,699,007	15.7%
Fentanyl	4,005.85	2%	9%	360.53	0.6	600,877,481	39.3%
Methadone	1,375.06	1%	100%	1,375.06	25	55,002,338	3.6%
Fentanyl mix	849.40	0%	9%	76.45	0.6	127,409,775	8.3%
Morphine	500.80	0%	100%		100	5,008,000	0.3%

[23] INCB, Psychotropic Substances 2019 (New York 2020).

	Seizures in kg equivalents	Distribution (based on seizures in kg equivalents)	Typical "purity" of substances seized	Purity adjusted seizures	S-DDDs ratios (incl. estimates for non-defined substances)	Purity adjusted seizures in S-DDDs	Distribution (based on purity adjusted seizures in S-DDDs)
				500.80			
Papaverine	60.23	0%	100%	60.23	100	602,275	0.04%
Pethidine	21.60	0%	100%	21.60	400	54,001	0.0%
Buprenorphine	17.74	0%	100%	17.74	8	2,217,544	0.1%
Oxycodone	14.07	0%	100%	14.07	75	187,590	0.01%
Carfentanil	7.65	0%	9%	0.69	0.01	68,858,820	4.5%
Hydromorphone	3.43	0%	100%	3.43	20	171,279	0.01%
Phenazocine	3.00	0%	100%	3.00	20	150,000	0.01%
Tapentadol (Nucynta, Palexia, Tapal)	2.98	0%	100%	2.98	175	17,034	0.001%
Oxycocet	1.53	0%	100%	1.53	75	20,365	0.001%
Percocet	1.38	0%	100%	1.38	75	18,375	0.001%
Subutex (buprenorphine)	1.25	0%	100%	1.25	8	156,194	0.01%
Oxycontin	0.70	0%	100%	0.70	75	9,300	0.00%
Suboxone (buprenorphine)	0.53	0%	100%	0.53	8	65,881	0.004%
Hydrocodone	0.14	0%	100%	0.14	15	9,630	0.001%
Dilaudid (Hydro-morphone HCL)	0.12	0%	100%	0.12	20	5,995	0.000%
Furanylfentanyl	0.09	0%	9%	0.01	0.6	13,437	0.001%
Oxyneo	0.02	0%	100%	0.02	75	220	0.000%
Diphenoxylate	0.004	0%	100%	0.00	15	270	0.000%
U-47700	0.004	0%	100%	0.00	13.33	300	0.000%
Ethylmorphine	0.001	0%	100%	0.00	50	18	0.000001%
Naloxone (buprenorphine)	0.001	0%	100%	0.00	8	75	0.000005%
Oxymorphone	0.0005	0%	100%	0.00	10	45	0.000003%
Pentazocine	0.0004	0%	100%	0.00	200	2	0.0000001%
Sub-total	214,595.30			92,127.59		1,396,661,224	91.3%
Other/non-specified	13,314.06			13,3148.06	100.00	133,258,640	8.7%
TOTAL	227,909.36			105,441.65		1,529,919,863.65	100.0%

Sources: UNODC calculations based on UNODC, responses to the annual report questionnaire, INCB, Narcotic Drugs 2020 (New York 2021) and INCB, Psychotropic Substances 2020 (New York 2021).

Trafficking routes and volumes

Information of trafficking routes was mainly obtained from analyses of reports by Member States in the annual report questionnaire and in individual drug seizures reported to UNODC, as well as analyses of trafficking routes reported by Member States.

Individual drug seizures would be the ideal data source for any in-depth analysis of drug flows. Unfortunately, reporting of individual drug seizure cases is very uneven. An average of 43 Member States reported individual drug seizures over the 2015–2019 period, and a significant portion do not provide information on trafficking routes or do so in a very limited manner.

Information for the maps was thus – primarily – based on information contained in the annual reports questionnaire, while individual drug seizures reports and official national documents were used to fill gaps.

Some of the maps have been also based on UNODC's Drugs Monitoring Platform which includes official information provided by Member States via their reporting on individual drug seizures to UNODC, other official reporting of individual drug seizures by Member States as well as individual drug seizures reported by the media. The coverage could thus be increased from, on average, 43 Member States officially reporting individual drug seizures per year to UNODC (or in total 86 countries over the period 2015–2019) to, on average, 119 countries and territories per year (or, in total, 168 countries and territories over the period 2015–2019). The number of reported individual drug seizure cases increased from, on average, less than 50,000 per year to more than 55,000 per year over the period 2015–2019. Nonetheless, the latter numbers remain small compared to the overall number of annual seizure cases reported by Member States to UNODC in the annual report questionnaire, amounting, on average, to around 2.5 million drug seizure cases per year over the period 2015–2019, reported by, on average, 70 countries and territories each year, or in total 102 countries and territories over the period 2015–2019.

Main trafficking routes as described by reported seizures

Seizures made in the various regions over the 2015–2019 period were used as a proxy for the importance of drug trafficking activities. Such seizures were distributed according to the countries of departure and transit mentioned by countries in the various regions for the period 2015–2019 (outside of the regions analysed), as weighted by the total reported seizures at the national level. This served as a basis for the calculation of (likely) importance of the various trafficking flows, taking into account that drugs could be seized at different stages along the trafficking route and drugs may need to travel across several sub-regions to reach the seizing country.

A similar approach was implemented using the countries of intended destination reported by the seizing Member States. Afterwards, the flows obtained from using reported departure/transit and destination information separately were put together to estimate the final relative size of the flow. This procedure was implemented at the sub-regional level to produce a matrix of flows across sub-regions. Afterwards, the main countries of departure or transit (and destination) were identified based on the weighted amounts that were seized while being trafficked from (to) them, according to reported seizures by Member States.

Drug price and purity data

Price and purity data, if properly collected and reported, can be powerful indicators of market trends. Trends in supply can change over a shorter period of time when compared with changes in demand and shifts in prices and purities are relatively good indicators for increases or declines of market supply. Research has shown that short-term changes in the consumer markets are first reflected in purity changes while prices tend to be rather stable over longer periods of time. UNODC collects its price data from the ARQ, and supplements this data with other sources such as DAINAP, EMCDDA and Government reports. Prices are collected at farm-gate level, wholesale level ('kilogram prices') and at retail level ('gram prices'). Countries are asked to provide minimum, maximum and typical prices and purities. When countries do not provide typical prices/purities, for the purposes of certain estimates, the mid-point of these estimates is calculated as a proxy for the 'typical' prices/purities (unless scientific studies are available which provide better estimates). What is generally not known is how price data and purity data were collected and how reliable the provided data are. Although improvements have been made in some countries over the years, a number of law enforcement bodies have still not established a regular system for systematically collecting purity and price data.

Prices are collected in local currency or in the currency in which the transactions take place and are then converted by UNODC into US dollars for the purposes of comparability among countries. The conversion into US dollars is based on official UN rates of exchange for the year. If comparisons of prices, expressed in US dollars are made over different years it should be noted that changes in such prices may be also influenced by changes in the exchange rates and may not necessarily reflect changes in the local markets.

Standardized prices of cocaine and heroin in the United States and Western Europe

The price and purity data used for the various figures found in the report are available under 8. Prices and purities of illicit Drugs (Tables) in the statical annex (World Drug Report 2021_Annex (unodc.org))

For the time series data for heroin and cocaine of Western Europe and the United States, the following methodology was used: For the case of heroin and cocaine prices in the 17 European countries in this Table, the published prices correspond an average of the available prices for the specific year (e.g., “crack” and cocaine salts, or white and brown heroin), if more than one type of drug is reported, or the typical value if only one price is reported by the country. In order to properly calculate the weighted averages across the 17 European Member States, in those countries for which no data is available, a “best estimate” is reported. This “best estimate” is based on: a) the latest reported value, b) an interpolation between two reported values, or c) the midpoint between the reported low and high observed prices (when a typical value is not available).

In order to properly reflect the prices faced by the population within these 17 countries, the average prices are weighted by the population. A reported average price per gram in Euro is also published based on the average exchange rates for the corresponding year, and the reported units (gram for retail, kilogram for wholesale). Finally, the inflation-adjusted weighted average is expressed in 2019 Euros, by deflating the prices using the Consumer Price Index (CPI) published by Eurostat.

For the case of heroin and cocaine average prices at the retail level in the United States of America, both series were reviewed last year given the availability of new data. Authorities from the United States of America provided UNODC with newly available quarterly data on the price and purity of cocaine and heroin at the retail level for the 2005-2018 period. The average quarterly price for each of these years is reported. For the year 2019, cocaine price data reported in reply to UNODC's annual report questionnaire were used while same typical price for heroin in 2019 as in 2018 was used as reported price ranges for heroin did not change between the two years. In the case of years prior to 2005, the yearly trends from the previously published series are used to retropolate the price available for 2005. These trends are based on ARQ data and data from ONDCP, *2015 National Drug Control Strategy - 2015 Data Supplement*.

In the calculation of purity adjusted average heroin prices, the purity provided by national authorities at the quarterly level are used for 2005-2018, while data available through the ARQ or published in ONDCP, *2015 National Drug Control Strategy - 2015 Data Supplement* are used for previous years. In the calculation of purity adjusted cocaine prices, data from ONDCP is also used up to the year 2004.

Inflation adjusted prices in the United States were deflated using the CPI, published by the Bureau of Labor Statistics. For inflation adjusted average drug prices in Western Europe drug prices were deflated using the Harmonised Indices of Consumer Prices (HICP) published by Eurostat for the Euro area.