

# New indicators to compare and evaluate harmful drug use among adolescents in 38 European countries

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## ABSTRACT

**AIMS** – New trends in drug consumption reveal increasing polydrug use. Epidemiological indicators in the current use are based on the prevalence and the associated potential harm of a single “main” substance. We propose new indicators to evaluate frequency and potential harm of polydrug use. The indicators are used to compare drug use among countries based on survey data on adolescents’ substance use in 38 European countries. **METHODS** – The approach is based on analysis of the frequency of use in the various population samples: lifetime use, twelve months use or last thirty days, depending on available data, and on the risk of harm for the substances used. Two indicators are provided: the frequency of use score (FUS) by summing the frequency of use of each substance, and the polydrug use score (PDS) that weight all the substances used by their risk. **RESULTS** – The indicators FUS and PDS were calculated and the distribution functions were used to characterise substance use across ESPAD countries. The analysis shows important differences in poly-substance use severity among countries presenting similar prevention policies. **CONCLUSIONS** – Systematic analysis of substance use and the related risk are of paramount interest. The proposed indicators are designed to better monitor and understand consequences of polydrug use and to measure the resulting risk at country or population level. The indicators may also be used to assess the effects of policy interventions.

**KEYWORDS** – adolescent drug users, frequency of use, polydrug use, incidence indicators, ESPAD

Submitted 25.04.2014

Final version accepted 08.09.2014

## Introduction

New trends in drug consumption create new challenges for monitoring and assessing the actual demand for drugs, the size of the drug market and the lifestyle of users. Drug consumption data reveal increasing levels, although still low, of polydrug use, even among adolescents, and concern is growing about additional risks of harm associated with polydrug use (EMCDDA, 2009; Ricci & Rossi, 2013). In fact, polydrug use has a significant public health impact, since the interaction of multiple

drugs can increase the level of neurological, physiological, and psychological harm to the user.

The problem of increasing polydrug use is well known to experts, and since 2009 polydrug use has been observed and monitored by the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA, 2009; 2012). A study based on data from the 2003 European School Survey Project on Alcohol and Other Drugs (ESPAD) examined polydrug to investigate differ-

ences among European countries with high, medium and low drug prevalence (Olszewski, Matias, Monshouwer, & Kokkevi, 2009).

Several studies have identified polydrug use as a risk factor for subsequent and more serious involvement in substance use (Mackesy-Amiti, Fendrich, & Goldstein, 1997; Galaif & Newcomb, 1999). The only exception appears to be “pure” cannabis users or, perhaps more appropriately, “cannabis-only” users (Santoro, Triolo, & Rossi, 2013). Furthermore, a recent study reported a positive association between the number of drugs used and self-reported suicide attempts (Kokkevi et al., 2012).

In contrast, epidemiological indicators to measure severity of harm from the use of various substances have not been well developed. For example, the EMCDDA collects key indicators of drug use, such as extent and patterns of drug use in the general population, problem drug use and demand for treatment by drug users, based on single substances or a “main” substance used without taking polydrug use into consideration. The aggregated standard tables provided by the national Focal Points consist of used in one’s lifetime, last 12-month and last 30-day prevalence rates for male and female users, by main substance, estimated from surveys in general or adolescent populations.

Some indices to quantify polydrug use have already been proposed, such as a count index, that simply sums the number of substances being used concurrently (Martin, Kaczynski, Maisto, & Tarter, 1993; Botvin et al., 2000; Siliquini, et al., 2001) or a weighted index, where each substance receives a weight based on its severity (Sneed, Morisky, Rotheram-Borusa, Lee, &

Ebin, 2004). Few studies have considered frequency or intensity of use of multiple substances. For example, a threshold determining intensive use of single substances was used to assess the number of users that exceeded the defined threshold in the use of more than one substance (Höhne, Pabst, Hannemann, & Kraus, 2013). Others assessed the severity of harm of any single substance and ranked substances by the resulting severity of harm score (Nutt et al., 2008 & 2010; van Amsterdam et al., 2010 and 2013).

New comprehensive indicators that allow measuring quantitatively the consequences of polydrug use are needed to overcome the limits of the single substance indicators currently being used. Also, clustering or ranking of countries with respect to polydrug use may be used to evaluate the impact of interventions, laws and policies, for example in terms of intended and “unintended” consequences.

Simple methods were developed in the 1990’s when polydrug use was marginal and the number of different psychoactive substances on the market was low. Presently, polydrug use represents a form of “normality” among frequent users (Ricci & Rossi, 2013; Fabi, Ricci & Rossi (2011) and more psychoactive substances appear on the market every year pushing polydrug use. In 2010, 41 new psychoactive substances were detected, 49 in 2011, 74 in 2012 and 81 in 2013 as reported by the EMCDDA and Europol (EMCDDA & Europol, 2014). The greater the number of substances available, the greater the need to measure the risk of harm from polydrug use. To a large extent, the health consequences of these new substances are unknown.

In this study, we applied the epidemiological indicators FUS and PDS to adolescent respondents of the European School Survey Project on Alcohol and other Drugs (ESPAD) in 2011 (Hibell et al., 2012), these indicators were introduced and explored both in adolescent users from the Italian School Population Survey (Fabi et al., 2011) and in adult users from four European countries (Fabi, Mammone, & Rossi, 2014). These indicators consider both the frequency of use and the harm of each substance used, providing a tool that can be used to evaluate demand reduction and primary prevention interventions, to compare countries to find best practices and to assess consequences of national drug laws and policies. Based on comparable data on substance use among 15 to 16 year old adolescents from 38 European countries in the year 2011, the present analysis aimed to: 1) define a global “frequency of use score” (FUS) and measure risk associated with use and polydrug use among adolescents with a “polydrug score” (PDS); 2) apply the two indicators to the 38 countries to measure the harm of drug use and polydrug use among adolescents; 3) explain how to compare different countries by inference methodology on indicators.

## Methods

Polydrug use was defined as concurrent use of more than one substance in a specific time period (Earleywine & Newcomb, 1997).

### Sample

Data from the 2011 European School Survey Project on Alcohol and Other Drugs (ESPAD) were used. A full description of sampling and data collection procedures

has been reported elsewhere (Hibell et al., 2012). In brief, ESPAD collects comparable data on substance use among 15- to 16-year old European students to monitor prevalence and patterns of use across countries. In the 2011 ESPAD study, students in 38 European countries were surveyed in a class room setting by completing self-administered questionnaires (total  $N = 111,583$ ). Countries participating were Albania, Bosnia and Herzegovina (Republic of Srpska), Bosnia and Herzegovina (Federation), Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Malta, Moldova, Montenegro, the Netherlands, Belgium (Flanders), Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Sweden, Ukraine, United Kingdom, Kosovo. Sample sizes varied between 366 and 6084 in Liechtenstein and Serbia, respectively.

### Instruments

Lifetime, last year, and last month frequency of use were recorded by asking respondents: “On how many occasions (if any) have you used <substance> in the particular time period.” Response categories were “never”, “once or twice”, “3–5 times”, “6–9 times”, “10–19 times”, “20–39 times” and “40 times or more”. Data on lifetime use were collected for 11 substances: tranquillisers and sedatives without prescription, cannabis, inhalants, cocaine, crack, heroin, hallucinogens (LSD and mushroom) and stimulants (GHB, ecstasy and amphetamines). Data on the use in the last year and the last month were collected for cannabis, ecstasy and inhalants.

### Analyses

The indicators “frequency of use” score and “polydrug use” score have been previously used in the analyses of the 2011 Italian School Population Survey (Fabi et al., 2011) and the 2012 PDU survey in Italy, the Czech Republic, Portugal and Catalonia (Ricci & Rossi, 2013; Fabi et al., 2014), considering prevalence data on substance use in the last 30 days. Here, the indicators FUS and PDS were calculated using lifetime consumption of 11 substances. Since respondents were aged 15 to 16 years at the time of the survey, “ever used” was considered representing recent consumption. Use in one’s lifetime was defined as the positive response to at least one of the drugs listed above. To response categories of lifetime frequency of use, (“never”, “once or twice”, “3–5 times”, “6–9 times”, “10–19 times”, “20–39 times”) were assigned the values 0, 1.5, 4, 7.5, 14.5, and 29.5 (times) respectively, representing the median value of each interval. For the last category “40 or more” an arbitrary frequency of 50 was chosen to be conservative, considering also that only a small number of respondents selected this category in at least one of the 11 questions (3% of males and 9% of females). Finally, the FUS indicator for each individual was computed by summing the median values of the frequency interval of each substance used within one’s in lifetime period.

The “overall” or global risk of harm weight for each substance was derived from the three indicators proposed by van Amsterdam et al. (2010) measuring different aspects of a substance’s negative health consequences: acute toxicity ( $X$ ), chronic toxicity ( $Y$ ) and dependence ( $Z$ ). Principal component analysis (Everitt & Dunn 1991,

pages 45-57 for a general introduction) was applied to the original indicators ( $X$ ,  $Y$ ,  $Z$ ) for the different substances, resulting in three new variables ( $W$ ,  $W'$ ,  $W''$ ), which are stochastically independent and provide, globally, the same information as the original ones. Since the variances explained by the three principal components ( $W$ ,  $W'$ ,  $W''$ ) were 77%, 14% and 9%, respectively, we decided to use the weight ( $a=0.338$ ,  $b=0.335$ ,  $c=0.348$ ) of the first component  $W$  to obtain the global risk of harm score, computed as  $W=aX+bY+cZ$  (Table 1). The polydrug score (PDS) for the  $i$ -th user was computed using the following formula:

$$PDS_i = \sum_{j=1}^n W_j FUS_{ij}$$

where  $n$  represents the number of substances used in the time period considered,  $W_j$  is the score of the  $j$ -th substance and  $FUS_{ij}$  is the frequency of use of the  $j$ -th substance for the  $i$ -th user in the same time period.

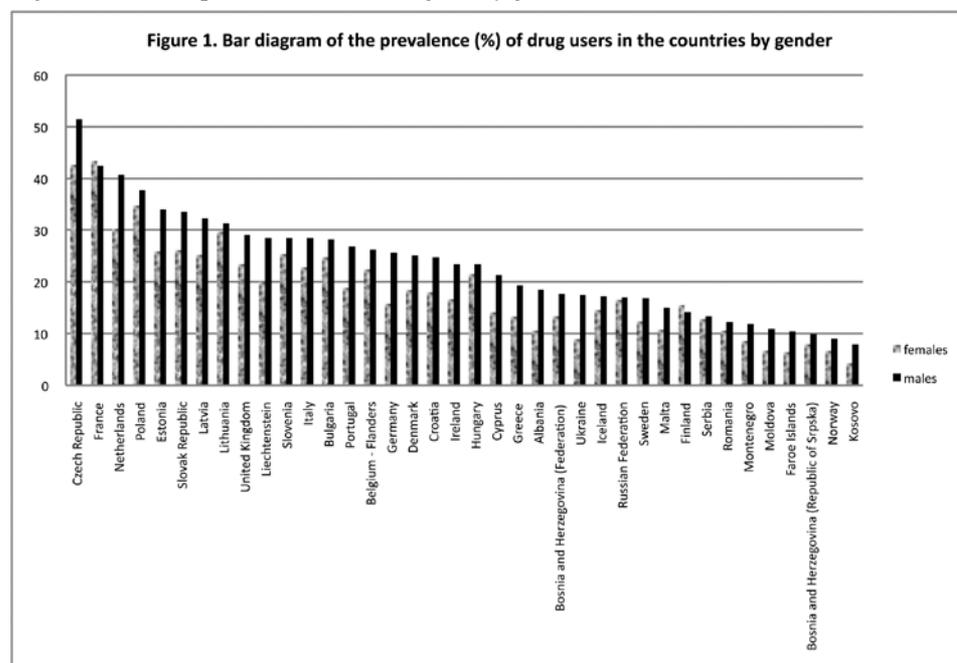
It is important to note that the PDS score has no upper limit and exhibited a very high variability. Although several “theoretical” upper limits can be defined, we choose to set the maximum theoretical value to 106.8, computed as the product between the maximum frequency of consumption (40 times) of the most harmful substance (crack cocaine, presenting a severity score  $W=2.67$ ). Dividing each value by the maximum theoretical value, we obtain a normalized score, thus comparisons among the 38 ESPAD countries are feasible.

Results are presented as mean or median, or as frequency (percentage). A  $p$  value  $< 0.05$  was considered significant in all statistical analyses.

**Table 1.** Indicators used for the principal component analysis: X, Y and Z (van Amsterdam et al., 2010) and average physical harm score (W) of the different substances obtained by the first principal component.

Substance	Overall physical harm score (W)	Acute toxicity (X)	Chronic toxicity (Y)	Dependence (Z)
Crack Cocaine	2.67	2.39	2.63	2.82
Heroin	2.51	2.37	2.03	2.89
Alcohol	2.18	1.89	2.47	2.13
Methamphetamine	2.18	2.03	2.18	2.24
Methadone	2.12	1.95	1.42	2.68
Cocaine	2.07	1.95	2.05	2.13
Amphetamine	1.88	1.71	1.89	1.95
GHB	1.47	1.84	0.79	1.71
Benzodiazepines	1.31	0.97	0.76	1.89
Buprenorphine	1.30	1.21	0.76	1.71
Cannabis	1.18	0.84	1.53	1.13
Ketamine	1.05	1.55	0.92	0.84
Ecstasy	1.03	1.34	1.34	0.61
Methylphenidate	0.87	0.92	0.83	0.86
Anabolic steroids	0.81	0.45	1.24	0.71
Khat	0.73	0.39	0.95	0.76
LSD	0.61	1.47	0.68	0.03
Magic mushrooms	0.28	0.89	0.13	0.03

**Figure 1.** Lifetime prevalence (%) of drug use by gender.



**Table 2.** Descriptive statistics for frequency of use score, in order from the highest to the lowest median value of FUS.

Country	Median	Mean	St Dev	Min	Max
France	7.5	19.94	26.87	1.50	400
Netherlands	7.5	19.55	28.27	1.50	324
Italy	7	21.89	34.66	1.50	341
Cyprus	5.5	26.2	46.97	1.50	349
United Kingdom	5.5	18.65	32.99	1.50	311
Belgium (Flanders)	5.5	17.74	25.60	1.50	209
Montenegro	4	23.94	50.66	1.50	353
Iceland	4	20.42	38.33	1.50	296
Malta	4	18.25	42.21	1.50	427
Bulgaria	4	17.18	32.40	1.50	339
Slovenia	4	16.98	31.45	1.50	348
Germany	4	15.77	24.26	1.50	202
Portugal	4	15.01	22.36	1.50	155
Liechtenstein	4	20.74	44.56	1.50	281
Ireland	4	18.98	42.14	1.50	365
Russian Federation	4	17.2	36.54	1.50	300
Hungary	4	15.76	30.78	1.50	368
Croatia	4	15.04	29.47	1.50	347
Denmark	4	13.98	22.73	1.50	211
Latvia	4	13.95	29.93	1.50	339
Slovak Republic	4	14.67	26.20	1.50	250
Poland	4	14.12	25.45	1.50	335
Czech Republic	4	15.59	24.53	1.50	282
Sweden	4	13.66	33.27	1.50	346
Finland	4	12.09	28.35	1.50	433
Estonia	4	10.49	18.01	1.50	226
Ukraine	3.5	13.24	35.31	1.50	377
Faroe Islands	3.5	5.89	9.98	1.50	50
Norway	3	13.69	29.53	1.50	219
Romania	3	10.42	20.65	1.50	174
Serbia	3	15.16	33.12	1.50	337
Greece	3	13.78	28.95	1.50	230
Lithuania	3	10.16	25.45	1.50	344
Bosnia and Herzegovina (Federation)	3	14.95	33.96	1.50	304
Moldova	1.5	6.57	19.74	1.50	242
Bosnia and Herzegovina (Republic of Srpska)	1.5	11.9	31.52	1.50	301
Albania	1.5	9.58	29.53	1.50	433
Kosovo	1.5	11.63	21.05	1.50	122
<b>Total</b>	<b>4.00</b>	<b>15.39</b>	<b>30.2</b>	<b>1.50</b>	<b>433</b>

**Table 3.** Descriptive statistics for normalized polydrug score, in order from the highest to the lowest median value of PDS.

Country	Median	Mean	St Dev	Min	Max
Italy	0.27	0.44	0.48	0	5.5
Bosnia and Herzegovina (Federation)	0.19	0.44	0.46	0.01	3.95
Albania	0.12	0.46	0.39	0	5.66
France	0.08	0.24	0.37	0	5.62
United Kingdom	0.08	0.23	0.47	0	4.73
Netherlands	0.08	0.23	0.38	0.01	4.64
Moldova	0.08	0.12	0.29	0	3.72
Cyprus	0.07	0.34	0.64	0	5.12
Belgium (Flanders)	0.07	0.21	0.33	0	3.27
Montenegro	0.05	0.3	0.72	0.01	5.58
Iceland	0.05	0.26	0.54	0	5.02
Malta	0.05	0.24	0.58	0	6.2
Bulgaria	0.05	0.21	0.44	0	4.62
Slovenia	0.05	0.2	0.42	0	4.98
Germany	0.05	0.19	0.31	0	2.36
Portugal	0.05	0.18	0.27	0	2.25
Liechtenstein	0.04	0.27	0.68	0.02	4.59
Ireland	0.04	0.24	0.61	0	5.16
Russian Federation	0.04	0.2	0.41	0	3.04
Hungary	0.04	0.2	0.42	0	4.89
Croatia	0.04	0.18	0.38	0	4.93
Slovak Republic	0.04	0.17	0.33	0	4.01
Poland	0.04	0.17	0.33	0	4.86
Latvia	0.04	0.17	0.42	0	5.05
Denmark	0.04	0.17	0.33	0	4.02
Czech Republic	0.04	0.17	0.28	0	3.51
Sweden	0.04	0.16	0.43	0	4.58
Norway	0.04	0.16	0.35	0	2.65
Ukraine	0.04	0.15	0.44	0	4.51
Finland	0.04	0.14	0.38	0	6.19
Romania	0.04	0.13	0.32	0	3.13
Estonia	0.04	0.12	0.21	0	2.68
Faroe Islands	0.04	0.07	0.12	0	0.55
Serbia	0.03	0.19	0.46	0.01	4.76
Greece	0.03	0.17	0.4	0	4.23
Kosovo	0.03	0.15	0.29	0.01	1.66
Lithuania	0.03	0.13	0.35	0	4.94
Bosnia and Herzegovina (Republic of Srpska)	0.02	0.15	0.44	0.01	4.26
<b>Total</b>	<b>0.04</b>	<b>0.21</b>	<b>0.41</b>	<b>0.00</b>	<b>6.20</b>

## Results

### *Lifetime use of any drug*

Figure 1 depicts the lifetime prevalence of any drug use by country. Countries are ordered by male prevalence from high to low. The highest prevalence for students that had used drugs was reported in the Czech Republic, France, the Netherlands, Poland and Slovak Republic and the lowest in Kosovo, Norway, Faroe Islands, Bosnia and Herzegovina (Republic of Srpska), Moldova and Montenegro. In general, the prevalence was higher in males than females except in France and Finland. In general, the male/female ratio was about one for cannabis, higher for cocaine and lower for tranquillizers.

### *Frequency of use score FUS and polydrug use score PDS*

The overall rank order of countries by FUS (range: 1.5-433) and PDS (range 0-6.2) are shown in Tables 2 and 3, respectively. A correlation analysis between FUS and PDS revealed that the relationship between indicators is positive, and is higher for the medians ( $\rho=0.81$ ,  $Z=8.27$ ,  $p<0.001$ ) with respect to the means ( $\rho=0.54$ ,  $Z=5.77$ ,  $p<0.001$ ) suggesting that the median values should be preferable to rank countries.

To illustrate the usefulness of the PDS score, the cumulative distribution for six countries (Czech Republic, France, Kosovo, Moldova, the Netherlands, Norway) is reported in Figure 2. Comparing, for example, the country-specific distributions at 0.9 of the y-axis, it is of note that in the Netherlands 90% of the respondents had PDS lower than 0.5, while in Norway the same percentage had a PDS lower than 0.1. We can conclude that the harm of polydrug use is lower in Norway with respect

to the Netherlands. The same approach can be used to compare other countries at different threshold levels of the cumulative distribution.

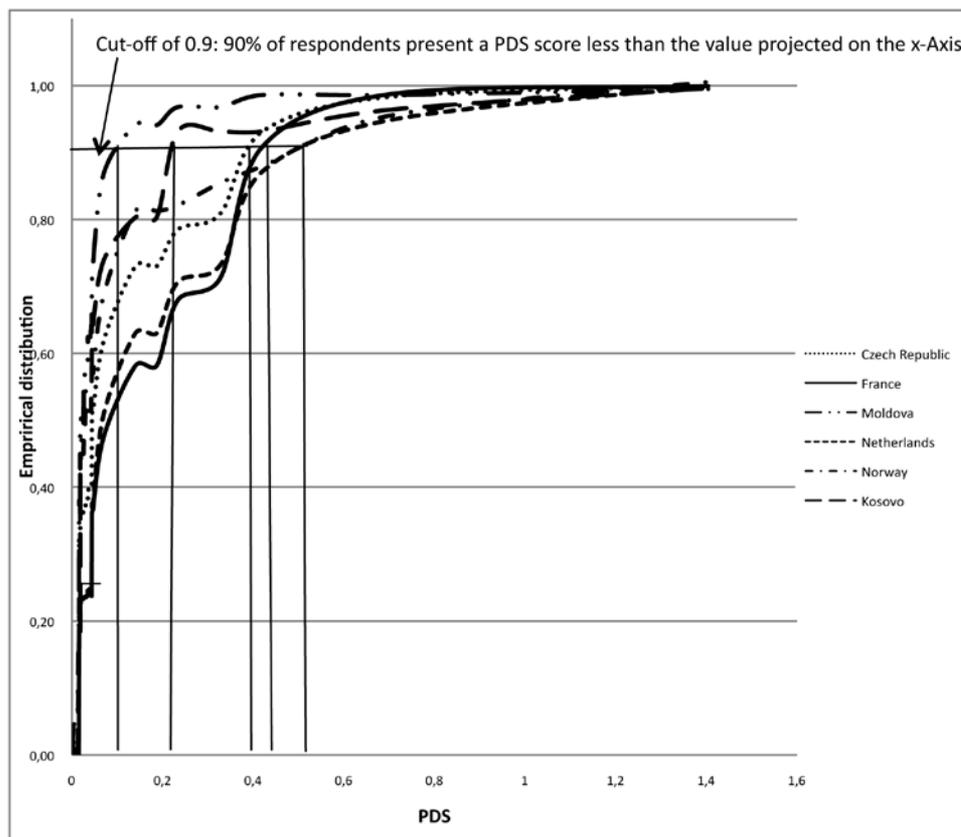
### *Clustering countries*

To highlight countries with similar patterns of polydrug use, the cumulative density function (CDF) of the normalized PDS was chosen to cluster countries. In particular the maximum value reached by the cumulative density function of normalized PDS was chosen as thresholds (Figures not shown, available on request) to obtain five different clusters (CDF  $\leq 0.10$ , 0.11-0.14, 0.15-0.20, 0.21-0.25, or  $>0.25$ ). Consequently, the first and the last cluster include countries with very small and very high levels of harm derived from polydrug use, respectively, while the other clusters include countries with medium-low to medium-high levels of harm derived from polydrug use.

Applying the procedure described above, the following results were obtained: Cluster 1 comprises Bosnia and Herzegovina (Republic of Srpska), Faroe Islands, Moldova, Montenegro, Norway, Kosovo; Cluster 2 comprises Albania, Bosnia and Herzegovina (Federation), Finland, Malta, Romania, Serbia; Cluster 3 comprises Croatia, Cyprus, Denmark, Germany, Greece, Iceland, Ireland, Russian Federation; Cluster 4 comprises Bulgaria, Hungary, Italy, Liechtenstein, Belgium (Flanders), Portugal, Slovenia, United Kingdom; Cluster 5 comprises the Czech Republic, Estonia, France, Latvia, Lithuania, the Netherlands, Poland, Slovak Republic.

Comparing the clusters obtained with PDS with prevalence of drug use (Figure 1) it is important to note that there is

**Figure 2.** Cumulative density function (CDF) of normalised polydrug scores (PDS) for six countries.



not a correspondence between PDS and prevalence. Considering, for example, Kosovo, Norway and Moldova, which have a prevalence of drug use around 8%-10% and appear in the first cluster of countries according PDS. Looking at Figure 2 and establishing a cut-off of 90%, we can see that the corresponding PDS scores are 0.1 for Norway, 0.4 for Moldova and 0.5 for Kosovo. This means that, although the prevalence is similar, the harm derived from polydrug use is higher in Kosovo and Moldova than in Norway. Following the same method and consider the Czech Republic, the Netherlands and France (Clus-

ter 5 with a prevalence of 46%, 38% and 42%, respectively) we can see that the corresponding PDS scores are 0.44 for France, 0.4 for the Czech Republic, and 0.5 for the Netherlands. Thus, for example, although the prevalence in the Netherlands is lower than in the Czech Republic, the risk of harm derived from polydrug use is higher in the Netherlands.

Finally, it could be useful to compare the clusters obtained with PDS, with clusters based on the mean or median value of FUS (Table 2). For example, if we chose to cluster countries with respect to the mean value of FUS, the first cluster (low level

**Table 4.** Descriptive statistics for normalised PDS means for the Czech Republic, Italy and Portugal. The p-value refers to Analysis of Variance.

	Czech Republic	Italy	Portugal	P
Sample size	968	673	211	0.005
Mean	0.17	0.44	0.18	
Standard error	0.0056	0.0032	0.0086	

of harm derived from polydrug use) would include Faroe Islands, Moldova, Albania, Lithuania, Romania and Estonia. However, Lithuania and Estonia were comprised in cluster 5 considering the cumulative density function of PDS. Although both indicators are based on the frequency of use, PDS gives a more complete picture about polydrug use with respect to FUS alone. Thus, indicators capable of summarizing several information about a complex phenomenon such as polydrug use, should be considered whenever possible.

#### *Comparing policies*

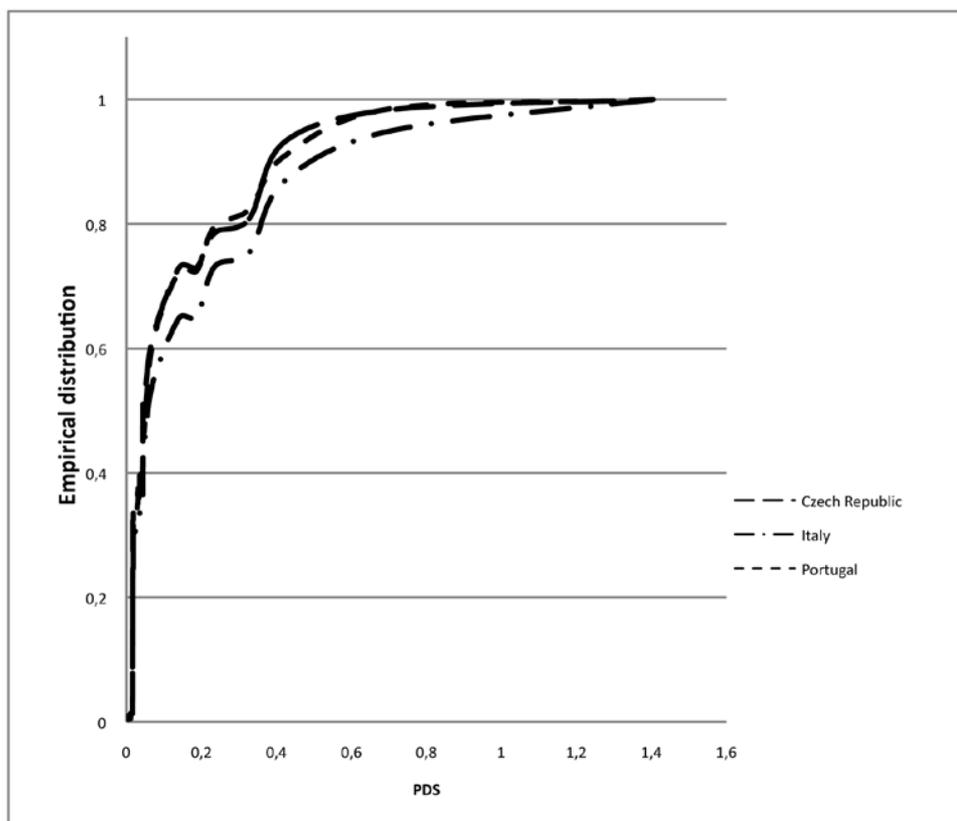
The proposed indicators FUS and PDS can be used and statistically compared for analyzing policy consequences. For instance, consider the drug laws in the Czech Republic, Italy and Portugal (Ventura & Rossi, 2013, Ventura, Wagner & Rossi, 2014). These three countries have decriminalized consumption and the main features of the law with respect to consumption are considered to be similar; their policies comprise prevention interventions. The new indicators FUS and PDS, however, allow comparing (and not just ranking) and understanding the effect of prevention interventions on drug use among adolescents. Consider the PDS means (Table 3) in the Czech Republic, Italy and Portugal. Comparing the three means, by analysis of variance, the result is significant with  $p < 0.05$ ,

meaning that there is a statistically significant difference among the means (Table 4). Post-hoc comparisons (Bonferroni adjustments) show that the PDS mean in Italy is significantly higher than in the Czech Republic ( $p < 0.001$ ) and in Portugal ( $p < 0.001$ ) due to more extensive polydrug use and greater consumption of hard drugs, while no difference was observed between Portugal and the Czech Republic ( $p = 0.67$ ).

Considering a different use of the indicators, let us compare male users' specific proportions obtained from the distribution functions shown in Figure 3. Suppose we wish to study now the proportion of users with a PDS below or above a certain threshold among countries, to evaluate potential differences in polydrug use. If we select a threshold for PDS of 0.19 for the Czech Republic, Italy and Portugal, we obtain the data reported in Table 5. The value of  $\chi^2$  is 13.1 and  $p < 0.001$ , so there is a statistically different proportion of users presenting a PDS of 0.19 or lower in the Czech Republic, Italy and Portugal (73%, 65% and 72% respectively) or higher than 0.19 (27%, 35% and 28% respectively). In particular, Italy presents the highest percentage of users having a PDS higher than 0.19 (35%), while the percentages in the Czech Republic and Portugal are similar (27%-28%).

This may be due to the type of preventive intervention in these countries (EMCDDA

**Figure 3.** PDS distributions to compare three countries with similar drug laws about consumption.



**Table 5.** PDS specific prevalence for the threshold equal to 0.19. Percentage are referred to column total. The P-value refers to  $\chi^2$  test.

PDS	Czech Republic	Italy	Portugal	Total	p
$\leq 0.19$	707 (73%)	437 (65%)	153 (72%)	1297 (70%)	
$> 0.19$	261 (27%)	236 (35%)	58 (28%)	555 (30%)	<0.001
<b>Total</b>	968	673	211	1852	

European Drug Report 2014). The Czech Republic uses interventions both for students and young people, Portugal targets only young people and in Italy no targeting exists. It is clear that Italy has fewer preventive interventions than the other two countries, particularly with respect to the Czech Republic. This could explain

why the PDS is significantly higher in Italy on the basis of hypothesis testing.

The comparisons we just discussed could be conducted for any set of countries, not just for countries presenting similar policies. Also, FUS could be used instead of PDS, or they can be used together. In the latter case, it should be considered

that results might be similar, since FUS and PDS are highly correlated.

## Discussion

The present paper introduced two scoring metrics measuring frequency and potentially harm of use and polydrug use as additional indicators in assessing the harm associated with multiple substance use in a country. Based on data of adolescents' drug use in thirty-eight European countries estimates of the traditional indicators were presented in addition to estimates of the new developed indicators frequency of use score (FUS) and polydrug use score (PDS).

The need for a rational scale to evaluate the risk of harm derived from substance abuse is discussed in many contributions such as Nutt et al. (2008, 2010) and van Amsterdam et al. (2010), although both deal with the consequences of the use of a single substances and not polydrug use. In a recent study new scores have been presented considering that "chronic" use at high doses of illicit drugs, alcohol and tobacco has been associated with physical disease (van Amsterdam et al., 2013). The authors also reported a novel score named "individual disease burden" which has similar meanings as the above described score W. A correlation analysis between the individual disease burden and the score W resulted in a correlation of  $\rho=0.91$ , showing the robustness of the approach to derive the score W.

To evaluate polydrug use, FUS and PDS were proposed. These two simple scores are uniquely determined, very intuitive, and easy to compute. The option chosen for standardisation enables comparisons between countries, user populations, or

settings aimed to reduce demand. The effectiveness of prevention measures may be evaluated by comparing the indicators of polydrug use before and after implementation, or between different countries, as shown in the example comparing the Czech Republic, Portugal and Italy, and their implementation of prevention interventions. Considered together with the prevalence of use, the indicators provide a more comprehensive picture of drug use: Prevalence of any substance use indicates the spread of substance use, FUS is a summary frequency measure across all substances, PDS weights every drug by the risk of harm associated with it and represents the overall harm associated with any substance use (single or poly-use). Time series analysis may be used to study the dynamics of drug use as soon as ESPAD data over a longer period are available. This analysis can be very useful to evaluate cost-effectiveness of different policies.

These indicators can be used to characterise substance use behaviour. For instance:

High prevalence of drug use combined with low PDS: Although drug use in these countries seems to be fairly widespread, prevention may work well because substances are taken at low frequencies and use of high risk substances is scarce; an example is the Czech Republic and Portugal.

Low prevalence of drug use combined with high PDS: Drug use in these countries is not widely prevalent; however, those who use drugs are at a high risk since their consumption of highly harmful substances is frequent. This pattern can be observed in countries from the former Soviet Union with past rigorous repressive drug policies. The harm associated with drug use in

these countries may be even more severe than in countries with a long tradition of substance use.

The results also demonstrate that classical indicators such as prevalence rates are not sufficiently informative without considering aspects of frequency and severity of polydrug use. For example, Italy (Cluster 4) has the highest values of the indicators in Table 2 and Table 3, showing that the harm of drug use is much higher than in other countries such as the Czech Republic (Cluster 5) as demonstrated in the example.

The indicators may be used to better describe countries by cluster analysis based on several dimensions. It is also possible to analyse drug policies and interventions in various countries by relating drug use patterns in different countries to drug regulations, prevention activities, or the state of the treatment system (Ventura et al., 2014). Repeated drug surveys such as the ESPAD study among adolescents may be used to assess, for instance, changes in severity of polydrug use over time. The changes may be analysed with respect to new or adopted drug laws, the emergence of new drugs, other significant drug market developments, or national reactions in drug policies such as the implementation of prevention interventions. Finally, the same indicators can be applied to different populations, such as General Population Survey or other populations involved in drug consumption.

The evaluation of drug use patterns and related risk of harm is not without limitations. First, as any assessment of stigmatized behaviour performed via surveys, self-reporting of drug use is not without reporting bias, and particular groups may,

for various reasons, decline participation. For instance, students not participating in school surveys are likely to miss school due to regular absenteeism, and this subgroup is well known to be at a higher risk of illegal drug involvement (Miller & Plant, 1999). Second, the proposed severity score is an overall measure that combines different patterns of use and drugs that are associated with different harm. For instance, a particular score may derive from highly frequent use of one or two highly harmful drugs or from low frequently use of several less harmful drugs. Although both patterns arrive at the same harm score, one may question that adding the possible harm of single substances covers the risk associated with the physical, psychological or social harm resulting from the interaction of various substances. While more research is needed in assessing the additional risk of harm resulting from the interaction of two or more drugs, the question of how many drugs are contributing to a particular score may be solved by address a count score.

Finally, it has to be noted that the scores provided by Van Amsterdam are useful, but they have also some limitations (i.e. they have been obtained using Delphi method). However, the flexibility of our approach permits the derivation of harm scores from other coefficients as well. In particular we intend to apply our method to the scores proposed in (Nutt et al., 2008) to evaluate differences and similarities.

Concluding, based on the present analysis the proposed scores of frequency of use (FUS) and polydrug use (PDS) provide two simple and intuitive measures that add the dimension of polydrug use to the existing

monitoring of prevalence and incidence of drug use (EMCDDA, 2012) and can help to quantitatively define the new EMCDDA indicator High Risk Drug Use (HRDU).

**Declaration of interest** None.

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