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Is There a Relationship Between Street Heroin Purity and Drug-Related Emergencies and/or Drug-Related Deaths? An Analysis from Vienna, Austria*

ABSTRACT: This study examines the quality of street heroin seized in Vienna in 1999 and whether there was a relationship between the purity of street heroin and the number of heroin-related emergencies as well as the number of heroin-related deaths. Street heroin confiscated by the Viennese police, run-sheets of drug-related emergencies, and postmortem reports of drug-related deaths in Vienna in 1999 were analyzed. A total of 415 retail samples with a total weight of 128.02 g contained a median percentage of 6.5% diacetylmorphine (range: 0.0–47.0%). All the samples contained a diluent, mainly lactose, as well as adulterants, such as caffeine and/or paracetamol. During the study period, 75 heroin-related deaths and 387 heroin-related emergencies were registered in Vienna. Time-series analysis revealed no statistically significant relationship between the rate of heroin-related incidents and the diacetylmorphine concentration of street heroin samples confiscated in Vienna in 1999. The widely held belief that the number of heroin-related deaths could be explained simply through fluctuations in the purity of street heroin could not be substantiated, even though the results of this study do not rule out an association between the purity of heroin and heroin-related deaths/emergencies.

KEYWORDS: forensic science, purity of street heroin, heroin-related deaths, heroin-related emergencies

Heroin use accounts for a high degree of morbidity and mortality, particularly among young people, predominantly in industrialized countries (1–4). In 2005, out of a total EU population of around 457 million, an estimated 1.2 to 2.1 million were problematic drug users, mainly related to heroin (5). The nationally estimated prevalence of drug use in Austria, a country with *c.* 8 million inhabitants, was found to be 2.2–3.3 per 1000 persons (aged 15–54 years), in 1999 (2). A number of 17,276 problematic opiate users in Austria and 10,953 in Vienna were estimated, representing 0.7% of the Viennese inhabitants (6). Since the late 1960s, the figure for drug-related deaths in Austria has been steadily increasing and peaked in 1994 with a total of 250 officially registered cases (7). The majority occurred in Vienna, the capital, with about 1.6 million inhabitants (8). Morphine is the most common illegal substance found in drug-related deaths in Vienna (9). According to the police information, Vienna in particular, may have been flooded with cheap heroin of higher quality after the fall of the Iron Curtain at the end of 1989 (10). In this context, it was a widely held belief that the increase in drug-related deaths, especially in the early 90s, was due to better quality heroin at a lower price (11,12). However, this hypothesis could not be substantiated by a study performed at the Department of Forensic Medicine of the Medical University of Vienna (13). Time-series analysis failed to establish any relationship between the quality of heroin confiscated by the Viennese police before and after the fall of the Iron Curtain and the number of heroin-related deaths from January 1, 1987, to December 31, 1995. Nevertheless, the study of the quality of heroin based on seizures carried out over various years has clear limitations. On the one hand, it is difficult to guarantee that seizures by law enforcement agencies constitute a representative sample of the end-user market. On the other hand, variations in drug prosecution policy or the decisions of judges in selecting the samples to be analysed could possibly undermine the reliability of such studies (14). Thus in Austria, for example, judicial proceedings can be dropped in cases involving the possession of a small quantity of heroin for personal use, usually <1.5 g of pure heroin (15). Another fact in a similar study is that police forward only aggregated data, with no data available on individual seizures (16). Furthermore, because of the fact that heroin-related deaths represent only a small part of heroin-related incidents, a connection between nonfatal heroin overdoses and heroin purity is also worth considering, when studying possible links between heroin quality and heroin-related incidents (17–19). None of the studies to date considered these aspects, either solely in connection with retail samples (20) or directly linked to heroin-related incidents (21).

Therefore, the aim of this study was to investigate whether there was a relationship between fluctuations in the purity of end-user retail samples (street heroin) and the numbers of heroin-related emergencies as well as of heroin-related deaths during one year.

Methods

Street Heroin Samples

For this purpose and in close cooperation with the Vienna Police Department, all street heroin samples confiscated by police officers

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between January 1, 1999, and December 31, 1999, were analysed using gas chromatography at the Chemical Laboratory of the Federal Ministry of the Interior in Vienna (22,23). If street heroin seizures consisted of more than one retail sample, each sample was individually analysed. The purity of confiscated street heroin samples was based on the concentration of diacetylmorphine in the sample expressed as a percentage on a weight/weight basis. Moreover, the total amount of opiates was also determined by adding the concentrations of diacetylmorphine and certain impurities such as 6-acetylmorphine, morphine, acetylcodeine, and codeine. These were also considered for statistical analysis.

Heroin-Related Emergencies

Ambulance run-sheets of the Vienna Ambulance Service regarding individuals involved in drug-related emergencies between January 1, 1999, and December 31, 1999, were analysed. An opiate-related emergency was assumed, if the diagnosis made by the Vienna Ambulance Service physician was based on clinical findings (Glasgow coma scale [≤12], impaired respiration [≤12 breaths/min], meiosis) and/or recovery after naloxone administration (3).

Heroin-Related Deaths

In Austria, an autopsy has to be performed in all cases of sudden death and death due to the possible culpability of a third party (24). Consequently, all drug-related deaths in Vienna are examined at the Department of Forensic Medicine. Drug-related deaths were defined according to edicts of the Austrian Federal Ministry of the Interior and EMCDDA, respectively (9,25). Evidence of drug consumption was determined by means of fluorescence polarization immunoassay (Abbott Diagnostics, Chicago, IL) and combined gas-chromatography/mass-spectrometry. Heroin-related death is usually because of respiratory failure (26). Thus, the concentration of morphine was determined in the medulla oblongata as well as in the blood. All blood and brain samples were tested for fentanyl. Blood alcohol was measured by means of gas chromatography. Poly-drug use was assumed if more than one drug, including alcohol, was detected in the corpse. Deaths due to heroin intoxication alone were classified as pure heroin-related deaths; deaths due to heroin use in combination with other drugs and/or alcohol were classified as poly-drug heroin-related deaths.

Statistics

The Shapiro–Wilk test was used to determine the correlation to a theoretical normal distribution. In case of abnormally distributed data, nonparametric tests were used, and the data were reported as medians and ranges. In case of normally distributed data, parametric tests were used and the data were reported as mean values and standard deviations (SD). To determine whether a relationship existed between the quality of heroin and heroin-related incidents, cross-correlation analysis as well as time-series analysis on a weekly basis by use of autoregressive integrated moving average methodology (ARIMA) were applied (27,28). All p-values are the results of two-sided tests. Differences are considered statistically significant at $p < 0.05$. SAS® (SAS Institute Inc., Cary, NC) and SPSS® for Windows® (SPSS Inc., Chicago, IL) were used for statistical analysis.

Results

Street Heroin Samples

From January 1, 1999, to December 31, 1999, a total of 201 street-heroin seizures confiscated by the Viennese police were analyzed at the Chemical Laboratory of the Federal Ministry of the Interior in Vienna (Fig. 1; Table 1). These 201 seizures comprised a total weight of 128.02 g heroin and consisted of a total of 415 retail samples which were individually wrapped in paper or cellophane (Table 1). All samples were in the base form and their color ranged from beige to dark brown. The median weight of heroin per seizure was 0.3 g and ranged from 0.2 to 7.1 g (Table 1). The number of retail samples per seizure ranged from 1 to 33 samples (Table 1). 70.6% of the seizures consisted of only one retail sample. The median weight of heroin per retail sample was 0.15 g and

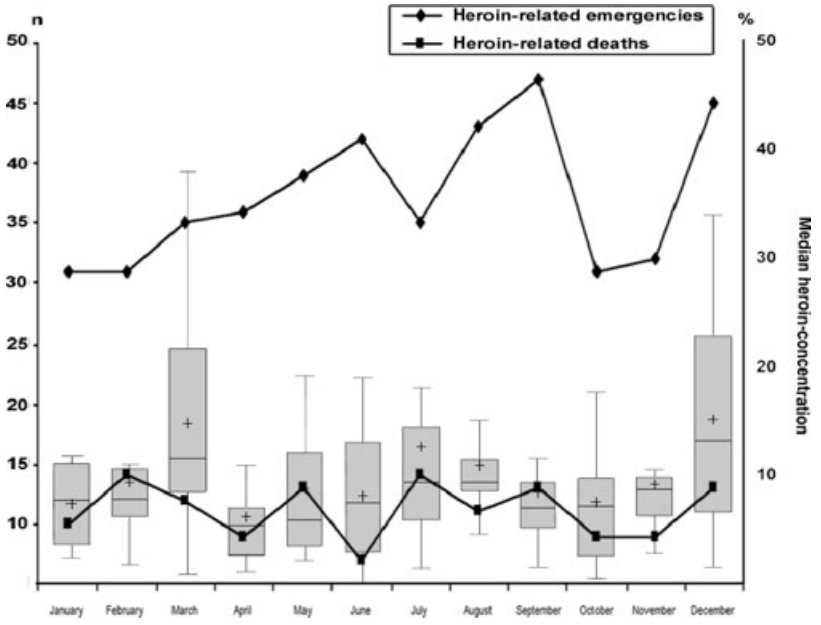

FIG. 1— *Boxplots (minimum, 25-percentile, mean [+], median, 75-percentile, maximum) of diacetylmorphine concentration (%) of street heroin samples (n = 415) and figures of heroin-related emergencies (n = 387) as well as of heroin-related deaths (n = 75) in 1999 in Vienna, Austria.*

TABLE 1—*Heroin-seizures, heroin-related emergencies and deaths in Vienna 1999.*

Heroin-Seizures	
Seizures (*n*)	201
Samples (*n*)	415
Weight (g)	128.02
Median weight of heroin per seizure (g)	0.3
Range weight of heroin per seizure (g)	0.2–7.1
Median weight of heroin per sample (g)	0.15
Range weight of heroin per sample (g)	0.1–2.8
Heroin-Related Emergencies	
Emergencies (*n*)	387
Individuals (*n*)	250
Females (*n*)	81
Males (*n*)	169
Females mean age (years)	26.6
Males mean age (years)	28.2
Heroin-Related Deaths	
Cases (*n*)	75
Females (*n*)	20
Females mean age (years)	26.1
Males (*n*)	55
Males mean age (years)	31.1
Only morphine (*n*)	16
Polydrug user (*n*)	59
Additionally Detected Substances	
Caffeine (*n*)	381
Caffeine median concentration (%) [range%]	29 [0.65–65]
Paracetamol (*n*)	379
Paracetamol median concentration (%) [range%]	36 [0.11–92]
Cocaine (*n*)	12
Cocaine median concentration (%) [range%]	15,5 [0.21–44.6]
Lidocaine (*n*)	3
Lidocaine median concentration (%) [range%]	35 [1.52–87]

ranged from 0.1 to 2.8 g (Table 1). The median percentage of diacetylmorphine (total amount of opiates) was 6.5% (8.2%) and ranged from 0.0% to 47.0% (0.5–55%). The percentage of diacetylmorphine as well as the total amount of opiates fluctuated statistically significantly over the 52-week study period, peaking in February and November (percentage of diacetylmorphine: $\chi^2 = 25.6$, d.f. = 11, $p < 0.05$; total amount of opiates $\chi^2 = 23.7$, d.f. = 11, $p < 0.05$; Fig. 2). All samples also contained impurities such as noscapine and/or papaverin as well as a diluent, mainly lactose. Moreover, in 381 samples caffeine (median concentration: 29% [range: 0.65–65%]), in 379 seizures paracetamol (median concentration: 36% [range: 0.11–92%]), in 12 samples cocaine (median concentration: 15.5% [range: 0.21–44.6%]), and in three samples lidocaine (median concentration: 35% [range: 1.52–87%]) as adulterants were detected (Table 1). In no sample, fentanyl could be determined/was detected.

Heroin-Related Emergencies

From January 1, 1999, to December 31, 1999, a total of 387 heroin-related emergencies were registered by the Vienna Ambulance Service (Table 1). These cases involved 250 individuals (Table 1). The study population consisted of 81 females and 169 males (Table 1). The number of contacts per individual ranged from 1 to 9. There was no statistically significant difference regarding age between females and males (females: 26.6 years [SD: 7.5] vs. males: 28.2 years [SD: 7.4]; $t = 1.6$, d.f. = 246, $p = 0.11$) (Table 1). There was no significant association either between age or gender, respectively, and the number of contacts with the Vienna Ambulance Service (Kruskall–Wallis test: $p = 0.53$; Wilcoxon-2-Sample test: $p = 0.34$).

Heroin-Related Deaths

From January 1, 1999, to December 31, 1999, a total of 75 heroin-related deaths were examined at the Department of Forensic Medicine (Figs. 1 and 2; Table 1). The study population consisted of 20 females and 55 males (Table 1). At the time of death, females were significantly younger than males (26.1 years [15.3–40.0] vs. 31.1 years [18.0–60.0] (Table 1); Wilcoxon-2-Sample test: $p < 0.05$). In 16 cases, only morphine could be detected, and these deaths were classified as pure heroin-related deaths (Table 1). In the remaining 59 cases, morphine, in addition to other CNS depressant drugs and/or alcohol, was detected (=poly-drug heroin-related deaths) (Table 1). Over the 52-week study period, there were no significant fluctuations in the degree of poly-drug involvement ($\chi^2 = -0.16$, $p = 0.13$). Poly-drug heroin-related deaths

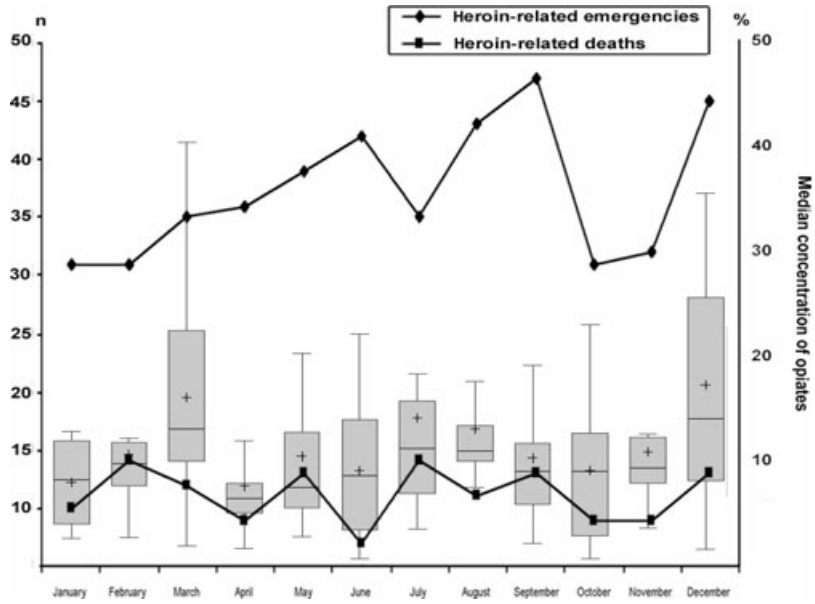

FIG. 2—*Boxplots (minimum, 25-percentile, mean [+], median, 75-percentile, maximum) of concentration of total amount of opiates (%) of street heroin samples (n = 415) and figures of heroin-related emergencies (n = 387) as well as of heroin-related deaths (n = 75) in 1999 in Vienna, Austria.*

were in an older population group than pure-heroin-related deaths (30.1 years [15.3–60.0] vs. 28.5 years [17.0–45.7]; Wilcoxon-2-sample test: $p < 0.05$). 29.6% of male heroin victims had additionally consumed alcohol, in contrast to 35.0% of female heroin users (Fisher's Exact Test: $p < 0.05$). There was no statistically significant association between blood alcohol concentration and morphine concentration in the medulla oblongata (Spearman rho = −0.24, $p = 0.42$).

The morphine concentration in the medulla oblongata/blood was almost the same in females and males (390 ng/g [100–1500] vs. 385 ng/g [35–1750]; Wilcoxon 2-Sample test: $p = 0.59$). There was no statistically significant difference between poly-drug heroin-related deaths and pure heroin-related deaths with regard to morphine concentration in the medulla oblongata (195 ng/g [58–1750 ng/g] vs. 205 ng/g [35–1250 ng/g]; Wilcoxon-2-Sample test: $p = 0.48$). There was no significant change in morphine concentration, neither in the medulla oblongata nor in blood over the 52-week study period (Kruskal–Wallis test: $p = 0.20$; Kruskal–Wallis test: $p = 0.36$). It must be noted that, because of the limited number of weeks in which no heroin-related deaths occurred, it was not possible to conduct time-series analysis of these data.

Heroin-Related Incidents and Heroin Purity

From January 1, 1999, to December 31, 1999, a total of 462 heroin-related incidents occurred in Vienna, in which 101 females and 224 males were involved (Figs. 1 and 2). The number of heroin-related incidents did not change to any great extent over the 1-year study period (January: 31 cases, and December: 48 cases, respectively; [$\chi^2 = 6.0$, d.f. = 11, $p = 0.87$]). Additionally, there was also no significant association between the number of heroin-related incidents and the day of the week or weeks, respectively ($\chi^2 = 47.86$, d.f. = 51, $p = 0.60$; $\chi^2 = 10.1$, d.f. = 6, $p = 0.12$). Differencing (prewhitening) the input variable "opiate concentration in samples" until the variance increases indicated that there was no integrated process, and there was an increase in the SD from 24.5 to 43.4 after differencing for the first time. Therefore, the unfiltered time series were used for further analysis. An autoregression analysis showed that there was no significant correlation in the input time-series or in any of the output time-series. Thus, the values per week are independent from previous and future weeks. Neither did cross-correlation reveal any significant differences. An ARIMA analysis of the median diacetylmorphine concentration in street heroin samples with regard to the number of heroin-related incidents showed that the observations in different weeks were statistically independent. There was also no relationship between the median concentration of the total amount of opiates in the samples and the drug-related deaths of heroin-related emergencies.

Discussion

The results of this study show that there was no statistically significant relationship between fluctuations in the purity of street heroin and the rate of heroin-related incidents during a 52-week study period in Vienna (Fig. 2). Time-series analysis based on ARIMA methodology as well as all correlation analyses for which fictitious significance could have played a role due to serial dependency did not reveal any statistically significant association. During this time-period neither the median concentration of diacetylmorphine (Fig. 2) nor the median percentage of the total amount of opiates of confiscated street heroin samples changed significantly. However, in this context it has to be considered that a positive correlation between the quality of confiscated heroin and heroin-related deaths alone would not prove that the purity of heroin is primarily responsible for fatalities (29–31). An increase in heroin quality may also reflect increased heroin availability. Thus, increased availability, accompanied by an increase in the number of users or in the frequency of use, would provide more opportunities for heroin-related incidents to occur (32). Nevertheless, drug concentrations *per se* are not usually determinative for cause of death. Toxicological data are no substitute for an entire case study and the exercise of medical judgement in the evaluation of death, because tolerance and other variables produce a wide range of lethal levels of chronically abused drugs (33). Furthermore, casual heroin users in particular, and people returning to heroin use after a period of abstinence such as imprisonment are at high risk of intoxication and death (34,35). In our sample, no information regarding drug-taking habits was available.

All street heroin samples were in the base form and contained impurities such as morphine, codeine, noscapin or papaverin, respectively. These substances may have been carried over from opium and/or from the production process in clandestine labs, and are referred to as impurities (36). Additionally, all samples analyzed for this study also contained caffeine, paracetamol and/or lidocaine; substances which are also designated as adulterants. These substances are thought to be added with the intention of altering the character of the heroin in some way. Thus, for example, in case of inhalation of smoke from heated aluminium foil ("chasing the dragon"), the addition of caffeine to the heroin base improves the amount of heroin that is present in the smoke (37). Other adulterants, such as quinine, procaine, strychnine or scopolamine, as described in other studies, were not detected (38–41).

Compared with reports from other countries, Viennese street heroin, with a median diacetylmorphine content of 6.5%, was generally of low quality. Heroin samples confiscated in Slovenia from 1997–1999 contained an average of more than 20% heroin (42). The average purity of heroin base in Germany in the 1990s was around 35%, with peak levels of more than 70% (42,43). In Switzerland, the U.K., Spain, and Denmark in the mid-1990s, the average purity of heroin base was about 40%, and ranged from 20–50% (2,36,38,44,45). The U.S. Drug Enforcement Administration reported an average increase in the purity of heroin from 6.9% in 1983 to 36.3% in 1996, whereby in north-eastern metropolitan areas of the U.S. where the majority of the nation's heroin addict population is believed to reside, the average retail level purity ranged from 55 to 75% (46). In New York City, the average purity of heroin increased from 3.8% in 1982 to 48.4% in 1991 (47). In New Jersey, in 1980, the average heroin purity was approximately 2%, yet at the end of the 1990s this had risen to around 60–70% (44). In Australia, in the early 1990s, the mean heroin purity was almost 60%, and ranged from 13% to 80% (31). Furthermore, in some samples which were sold in Vienna as heroin, no diacetylmorphine was detectable.

In almost 80% of heroin-related deaths, morphine in combination with another drug and/or alcohol was detected. This finding is consistent with the results of former studies performed at the Department of Forensic Medicine in Vienna, in which a statistically significant increase of poly-drug involvement since the late 1980s has been revealed (9,13). Similar findings are described by Coffin et al. (48). In this context, it must be considered that the coadministration of other CNS depressant drugs such as alcohol or benzodiazepines can substantially increase the likelihood of a fatal outcome following the injection of heroin, this being due to the potentiation of the respiratory depressant effects of heroin. On the other hand, in our study population there was no statistically significant association between the morphine concentration in the

medulla oblongata and poly-drug involvement or blood alcohol levels, respectively (39,49).

Based on the finding that, in our study population, 20% of heroin-related deaths were purely heroin-related, and that those so dying were significantly younger than those dying in poly-drug heroin-related deaths, it could be suggested that in 1999 only a small proportion of heroin-related deaths were due to novice heroin use in Vienna.

It should, however, be noted that this study was performed on the basis of relatively few heroin samples ($n = 415$ with a total sample weight of 128.02 g of heroin) in a city with an estimated 10,953 problematic drug users, mainly intravenous heroin users.

In conclusion, street-heroin sold in Vienna was generally of low quality, and in base form with a high proportion of added caffeine, which is more suitable for smoking than for injection. Even though the results of this study do not rule out that some accidental heroin-related deaths and/or heroin-related emergencies in Vienna in 1999 occurred because addicts purchased heroin with an unexpectedly high content of diacetylmorphine and/or total amount of opiates, the widely held belief that especially the number of heroin-related deaths could simply be explained by fluctuations in the purity of street-heroin could not be substantiated. However, based on our finding that the majority of drug-related deaths in Vienna were due to heroin use in combination with other CNS depressant drugs and/or alcohol, measures to reduce poly-drug use should be taken.

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