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An exploratory study of information sources and key findings on UK cocaine-related deaths

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Abstract:	Cocaine-related deaths have increased since the early 1990s in Europe, including the UK. Being multi-factorial, they are difficult to define, detect and record. The European Monitoring Centre for Drugs & Drug Addiction (EMCDDA) commissioned research to: describe trends reported to Special Mortality Registries (SMRs) and General Mortality Registers (GMRs); provide demographic and drug-use characteristic information of cases; and establish how deaths are identified and classified. A questionnaire was developed and piloted amongst all EMCDDA Focal Point experts/SMRs: 19 (63%) responded; nine countries provided aggregated data. UK GMRs use cause of death and toxicology to identify cocaine-related deaths. Categorisation is based on International Classification of Diseases (ICD) codes. SMRs use toxicology, autopsy, evidence and cause of death. The cocaine metabolites commonly screened for are: benzoylecgonine, ecgonine methyl ester, cocaethylene and ecgonine. The 2000s saw a generally accelerating upward trend in cases, followed by a decline in 2009. The UK recorded 2700-2900 deaths during 1998-2012. UK SMR data (2005-9) indicate: 25-44 year-olds account for 74% of deaths; mean age = 34 (range 15-81) years; 84% male. Cocaine overdoses account for two-thirds of cases; cocaine alone being mentioned/implicated in 23% in the UK. Opioids are involved in most (58%) cocaine overdose cases.

An exploratory study of information sources and key findings on UK cocaine-related deaths

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Glossary

ATS	Amphetamine-type stimulants
COD	Cause of death
DRD	Drug-related death
EMCDDA	European Monitoring Centre for Drugs and Drug Addiction
GHB/GBL	Gammahydroxybutyrate/Gammabutyrolactone
GMR	General Mortality Register
ICD-10	International Classification of Diseases and Related Health Problems 10th Revision
'Legal highs'	Licit drugs (chiefly stimulants such as cathinones, synthetic cannabinoids, etc. which may or may not have become regulated/controlled during the time-period examined by this project)
MDMA	Methylenedioxymethylamphetamine
NFP	National Focal Point
NPS	Novel Psychoactive Substances
NPSAD	National Programme on Substance Abuse Deaths
PM	post mortem (autopsy)
SMR	Special Mortality Registry
UK	United Kingdom

Introduction

There has been increasing prevalence of cocaine use in some countries, and indications of increased number of cocaine deaths in some European countries up to the end of the first decade of the present century (in excess of 1,000 in 2007–8). Deaths were still at high levels in 2011, at least 475 deaths in 17 countries, (EMCDDA, 2011; 2013a, 2013c), and at least 800 were reported from 27 countries in 2013 (EMCDDA, 2015:45). In addition, there is evidence of a considerable burden of morbidity related to cocaine use in Europe (Mena et al., 2013; EMCDDA, 2013b, 2014). High mortality among cocaine users has been documented in different parts of the world, including Europe (Degenhardt et al., 2011; Barrio et al., 2013; Pavarin, 2013; de la Fuente et al., 2014).

In the wider context, other factors have been shown to be related to cocaine-related deaths, these include a: positive correlation with 'last year' use of cocaine powder, number of offenders, and number of seizures, but negatively with price (Schifano and Corkery, 2008). Furthermore, such deaths are correlated positively with the numbers of crack offenders and seizures, but negatively with crack purity and price.

Cocaine-related deaths are underestimated as they are more difficult to define, detect and record as such in mortality registries compared to, for instance, to heroin-related deaths - more particularly in some countries' General Mortality Registers (GMRs) due to coding practices. The characteristics of cocaine deaths are multi-factorial (socio-demographics, toxicology, circumstances and mechanism of death), and are often different from opiate/opioid deaths and may not be collected by GMRs (Corkery, 2012; EMCDDA, 2013a).

A project was commissioned to provide better information on the numbers and characteristics of cocaine-related deaths in Europe, to complete and deepen the information usually provided on drug overdose deaths (drug-induced deaths) to the European Monitoring Centre for Drugs & Drug Addiction (EMCDDA, 2010). This element complements the current routine data collection on drug-induced deaths by the EMCDDA, which provides only limited information on cocaine-related deaths. The project attempted to establish how cocaine deaths are identified and classified, and gauge the level of, and possible reasons, for under-reporting. It is a seminal study in the context of understanding European cocaine deaths, providing fundamental information on such events generally, including causes and mechanisms of death, case demographics, substances involved, and case identification.

This paper focuses on the UK, presenting sources of information used to collect data, and updates information on trends in cocaine-related deaths reported from 1998 to 2012. It discusses the (public) health implications and the gaps in data currently available, to inform future data collection, analysis and research.

Methodology

This paper draws on data collected as part of an EMCDDA project aimed to describe the trend in numbers of cocaine-related deaths reported to Special Mortality Registers (SMRs) (or GMRs where relevant) (Corkery, 2012). It also uses insights from a complementary study on cocaine-related hospital emergency admissions (Mena et al., 2013) and other published data.

Two sources of information were used in the UK context. First, all three UK GMRs (the Office for National Statistics (ONS) covering England and Wales; the General Register Office for Scotland (GROS), part of the National Records of Scotland (NRS); the General Register Office for Northern Ireland (GRONI) and the Northern Ireland Statistics & Research Agency (NISRA) extract deaths related to poisonings by drugs, medicaments, etc. using ICD-10 codes (WHO, 1992, 2010) for adding to special databases set up to monitor DRDs (Christophersen et al., 1998). Text searches of the wording of the medical cause(s) of death are then employed to assign deaths to specific classes of drugs or specific substances as listed in their annual publications on such fatalities (NISRA, 2016; NRS, 2016; ONS, 2016). The case definition used to extract the cocaine-related cases was 'all cases with cocaine mentioned in the cause of death'. Only published statistics were accessed.

The second source used was the UK SMR – the National Programme on Substance Abuse Deaths (NPSAD), based at St George's University of London. The Programme receives information from coroners on a voluntary basis on deaths related to drugs in both addicts and non-addicts in England and Wales, Northern Ireland, the Channel Islands and the Isle of Man. From 2004 to 2011 information was also received from the Scottish Crime and Drug Enforcement Agency, and from 2004 onwards from the General Register Office for Northern Ireland. Since 1997 details of more than 30,000 deaths have been received. The average annual response rate from coroners in England and Wales to NPSAD during the period focussed on in this study, i.e. 2005-9 was between 89% and 95% (Ghodse et al., 2010).

To be recorded in the NPSAD database as a drug-related death, at least one of the following criteria must be met: (a) presence of one or more psychoactive substances directly implicated in

death; (b) history of dependence or abuse of drugs; or (c) presence of controlled drugs at post-mortem (Corkery et al., 2014). Internal analysis by the NPSAD team in 2009 indicated that for deaths which occurred in England in 2007 and 2008, 47.7% met all three criteria, between 49.3% and 81.5% met at least two criteria, and between 1.7% and 11.3% met only one criterion. These proportions were similar in both years. The basic approach used by the Programme to identify cases involving specific substances is a text search of the cause of death field. However, where a death is described as “multiple drug overdose” (or similar wording) information in the text of the coroner’s verdict may be useful for identification of specific substances involved. In addition, reference may be made to the autopsy and/or post mortem toxicology (PM) reports, with special attention being paid to the concentrations of relevant substances and/or their metabolites. These data, together with the coroners’ verdicts are used in the allocation of ICD-10 codes. For further information see Corkery et al. (2014). Two categories of cases were extracted from the NPSAD database: first, ‘all cases with cocaine mentioned in the cause of death’; and second ‘all cases with a positive toxicology for cocaine and/or its metabolites, whatever the cause of death’. The data from the GMRs and NPSAD are not directly comparable but do complement each other; the key differences between the ONS and NPSAD are described in Table 7 of Stephenson and Richardson (2014).

Trend data presented here for the period 1998-2012) extend the data presented in the formal EMCDDA project report (Corkery, 2012). For all cases with cocaine mentioned in the cause of death, the total numbers of cases are given for any cocaine combination and whether cocaine was the sole substance. For NPSAD cases retrieved for the period 2005-9 with cocaine mentioned as a cause of death, the gender, age-group, and detailed toxicology findings were

recorded (i.e. other substances identified). Information on whether the death was overdose (toxicity, intoxication, poisoning, etc.) or not overdose related was also retrieved.

Part I of the Cause of Death on the death certificate or Medical Certificate of Death (for an example of the latter, see Figure 1) should record the causal chain of morbid conditions that led to death, beginning with the condition most proximate to death on line (a) and working backwards to the initiating condition. The lines (a) to (c) in Part I are connected by the phrase 'due to, or as a consequence of'. Part I is designed to facilitate the selection of the underlying cause of death when two or more causes are recorded on the death certificate. Part II seeks other conditions that the certifier believed contributed to death, but were not in the causal chain. There can be an overlap between these categories in terms of the role which cocaine plays, e.g. post mortem (PM) toxicology reveals a lethal level of cocaine which causes death by poisoning. Many cases meet both criteria. However, cocaine may be detected through PM screening or analysis but at 'trace' levels without having contributed to the death, e.g. a car passenger who has consumed cocaine some time before being killed in a fatal road traffic accident.

< Figure 1 about here >

In order to establish whether or not any changes in trend were statistically significant or not regression analysis was undertaken using Joinpoint Trend Analysis Software Desktop version 4.2.0.2 (http://surveillance.cancer.gov/joinpoint/). This statistical software permits the analysis of continuous linear trends with change points, i.e. joinpoints, to test whether an apparent change is statistically significant. This approach has been primarily used in cancer research, but has also been employed to look at trends in opioid analgesic and heroin-related deaths (Warner et

al., 2014), ~~and~~ methadone-related overdose deaths (Wunsch et al., 2013), and excess mortality in cocaine users (de la Fuente et al., 2013).

Results

General trends and key findings

Between 1998 and 2012, the period for which data were available for this study, there were 2728 cases of deaths where cocaine was mentioned in the cause of death, registered in the UK by the 3 GMRs. A third (845; 31%) of these deaths had cocaine only mentioned (Table ~~2~~1). During the same period, the SMR was notified of 2907 relevant cases where cocaine was implicated in the cause of death, of which 510; 17.5% had only cocaine mentioned. There were 4100 cases received by the SMR where cocaine was recorded in the PM toxicology (of which 333; 8.1% (range 3.0-9.6% over the period examined) were sole mentions). Over the period 1998-2012, 87% of cases where cocaine was implicated in death were regarded, in terms of underlying cause of death, as poisonings or overdoses according to ICD-10 codes.

Trends

GMR. Figures for the number of registered deaths published (NRS, 2016 for Scotland; NISRA, 2016 for Northern Ireland; ONS, 2016 for England & Wales) by the three GMRs covering the UK show that any mentions of cocaine in the medical cause of death field on the death certificate totalled 2728 between 1998 and 2012. Such mentions generally rose year on year from 1998 (n=69) to 2008 (n=325), but subsequently fell in 2011 (n=171) before increasing slightly in 2012

(n=191) - see Table 2. This pattern was echoed by sole mentions. At the UK level, the number of sole mentions rose from 28 in 1998 to 101 in 2008, but fell to 37 by 2011, rising again to 42 in 2012. The ratio of any to sole mentions of cocaine on UK death certificates during the period 1998–2012 averaged 3.23:1 (2728/845) (range 2.20:1 to 4.62:1). The proportion of cases accounted for by sole mentions of cocaine in the cause of death field on UK death certificates averaged 31.0% (range 21.6-45.5%) over the period 1998-2012.

SMR (NPSAD). In total, 2907 cocaine-related deaths occurring in 1998-2012 were notified to NPSAD by September 2013. The number of cases in which cocaine was implicated in the cause of death (for any type of cocaine-related DRD) rose from 83 in 1998 to 263 in 2002, before falling in 2004 but then peaking at 321 in 2007, decreasing to 156 by 2010, increasing in 2011 (n=167) and falling again in 2012 (n=137). In respect of sole mentions, this same pattern obtained: the number rose from 8 in 1998 to 67 in 2008, but fell to 29 by 2012 (geographical coverage was poorer in the first few years of the Programme's operation, which may account for some of this difference). The overall ratio during this period of any to sole mention was 5.70:1 (2907/510) for cause of death (range 10.38:1 to 3.89:1). The overall proportion of sole cocaine mentions in the cause of death during the period 1998-2012 was 17.5% (range 9.6-25.7%).

A total of 4100 deaths in which PM toxicology reports had any mention of cocaine were notified to NPSAD in the period 1998-2012. Such cases generally rose year on year from 1998 (n=83) to 2007 and 2008 (n=476), but subsequently fell to 242 in 2012. In respect of sole mentions, a similar pattern was present, rising from 8 in 1998 to plateau about 36–37 in 2005–7 but falling to 10 by 2012. The overall proportion of sole cocaine findings in PM toxicology during the period 1998-2012 was 8.1% (range 3.0-19.6%).

< Table 1 about here >

Depending on the data source, the peak in cocaine-related deaths occurred in either 2007 (SMR) or 2008 (GMR). (The SMR uses the year of occurrence of death, whereas the GMRs report year of death registration.) Overall, a consistent pattern emerges from a comparison of the GMR and SMR trend figures (Figure 1).

< Figure ~~1~~2 about here >

The results of Joinpoint regression analyses indicate that all six datasets investigated have a single joinpoint (Figure 2). Five out of the six joinpoints occurred in 2007 or 2008, only that for the SMR any cause of death mention is outside this period (2002). All these results are statistically significant ($p < 0.05$). See Table 2 for full details.

< Figure ~~2~~3 about here >

< Table 2 about here >

Key demographic characteristics

Detailed demographic and other information are not published by the UK GMRs in respect of specific substances. The key characteristics for UK SMR cases in 2005-9 where cocaine was mentioned in the cause of death are given in Table 3. The main findings are: the mean age at

death during the period was 34.3 years (range 15.6 to 81.3, standard deviation = 9.0). About 89% were aged less than 45 years old, 56% were less than 35 years old. The majority were male (84%); and where ethnicity was known, the majority (88%) were White. Where information was available, 49% were employed, 54% lived with others, 82% had a history of drug use/addiction, and at least 7% of the general ~~sample were~~sample was known to be injectors.

<Table 3 about here>

Underlying cause of death

Out of the 1234 deaths during 2005-9 which involved cocaine in the cause of death, 1082 (87.7%) were ascribed an underlying cause as a poisoning or overdose (Table 4). Of the remaining 152 cases, about 14 (1.1%) could be described as "general medical condition", together with 21 (1.7%) having cardio-vascular and related problems, hanging 36 (2.9%), injuries 10 (0.8%), mental & behavioural disorders 51 (4.1%), drowning/falls 3 (0.2%), and road traffic accidents 5 (0.4%).

<Table 4 about here>

Substances implicated

The mean number of post mortem drugs was 3.4, underlining the role of poly-substance use. In the majority of cases, opiate/opioids (alone or in combination with other substances) are the main feature of cocaine-related DRDs reported to the UK SMR: implicated in 58.2% of cause of

death cases in 2005-9 (Tables 5 and 6). Other key substances implicated were alcohol (30% of cases), drugs for anxiety/insomnia~~hypnotics/sedatives~~ (mainly benzodiazepines, especially diazepam) (18%), drugs for depression~~anti-depressants~~ (9%), MDMA (5%), and amphetamines (5%). The most frequent combinations of substances (Table 6) involve alcohol, medications (excluding opiates/opioids), opiate/opioids, drugs for anxiety/insomnia~~hypnotics/sedatives~~, and other recreational drugs (amphetamines, ecstasy, etc.). More recently, Novel Psychoactive Substances (NPS) have been seen in cocaine-related deaths; during the period 2005-9 the NPS concerned were piperazines.

<Table 5 about here>

<Table 6 about here>

Identification and classification of reported cases

The UK GMRs and SMR distinguish cocaine poisonings from other types of deaths. Poisonings and somatic (i.e. those relating to the body as opposed to mental and behavioural disorders) deaths overlap; it can be difficult to distinguish between them. Apart from cocaine itself, the principal metabolites commonly identified or screened for are: benzoylecgonine, ecgonine methyl ester, cocaethylene and ecgonine. The products of combustion can be a means of distinguishing smoked cocaine/crack from other modes of intake. However, toxicologists are not usually looking for such products. Information on the use of crack immediately prior to death usually comes from police examination of the death scene and/or witness statements. The GMRs and SMR do not distinguish crack from powder cocaine in their publications.

Discussion

This paper presents data on what we believe to be the largest number of cocaine-related deaths reported to date, drawing on both GMR and SMR records. Whilst the extent of overlap between the two can be seen in respect of case definitions (Corkery, 2008), the extent to which identification of identical cases for specific drugs occurs can only be established by a dedicated study matching records for individual decedents. Factors which would have to be taken into account include: geographical coverage/reporting compliance; degree of ambiguity over the contribution of index drugs in cause of death described as 'multiple drug overdose', etc.; availability of detailed toxicology; under-identification of non-overdose deaths involving index drugs.

Case identification

In many cases, it is difficult to ascertain if a death was primarily due to cocaine poisoning, or whether it was due to a combination of substances, or the result of a pre-existing health condition precipitated by cocaine use. Compared to the UK, it has been unclear how cocaine deaths are identified in Europe. In particular, deaths occurring shortly after, and induced by, cocaine use, but which are not poisonings in the strict sense (i.e. overdoses), may not have been identified as induced by cocaine, and therefore are not reported (EMCDDA, 2007:19-20). The EMCDDA study found a range of approaches is used to retrieve cocaine-related cases from mortality registries (Corkery, 2012). There are complexities around variation in ICD coding, PM investigation, as well as the identification and reporting of cases in the first instance, e.g.

distinguishing between clearly direct causality and other factors in particular types of cases (e.g. accidents). Clearly, the lack of consistency in the definition of cocaine-related deaths by UK GMRs and SMRs, as well as databases across Europe makes some inferences from data unreliable, as well as the aggregation of data and between-country comparisons. Two of the three UK GMRs do not have access to post mortem toxicology, and the third only has some indication from pathologists as to possible drugs implicated (NRS, 2015). A wider range of factors is used by NPSAD, facilitating greater flexibility in approach: toxicology, autopsy, evidential information and cause of death.

Representativeness

Levels of under-identification and reporting cannot be gauged without undertaking further investigations to establish in detail the full range of reasons for under-reporting and their extent. However, NPSAD has been receiving access to all Northern Ireland drug poisoning deaths data. Some information is available on comparisons between Scottish Crime & Drug Enforcement Agency (SCDEA) and the Scottish GMR (now NRS) data for 2006 deaths. A core number of 321 deaths were counted by both the GMR and SCDEA; 100 deaths were counted by the GMR but not by SCDEA; and 53 cases were counted by SCDEA but not by the GMR (see Annex B of NRS, 2016). An audit of coronial files found that 3-4% of relevant cases had not been reported to NPSAD (Ghodse et al., 2010).

One cannot simply add together the figures from GMRs and SMRs to establish the absolute number of cocaine-related deaths~~DRDs~~. The extent of overlap between cases recorded by the UK GMRs and NPSAD is not known in respect of drug-induced deaths generally nor for

cocaine-related deaths ~~DRDs~~ specifically. However, it is known that there are benefits in using these two different but complementary sources. They can each be used to cross-check or validate the findings of the other (i.e. triangulation). They are not alternatives since they have different functions.

It would be beneficial to both the GMRs and NPSAD to be able to exchange information on named individuals on a regular and routine basis so that all relevant cases are identified, and thus both databases made more complete and accurate. The extent of overlap between them needs to be established. However, legislation restricts the way in which the GMR for England & Wales can share information with non-Governmental bodies; this limits the extent to which information can be exchanged between the two bodies. For ad hoc studies it is necessary for the SMR to register that specific project as a medical study. Consideration could be given to see if such an arrangement could be extended to the surveillance work as a whole, or to an alternative mode of working. For this reason, we did not compute rates of cocaine-related mortality which could be misleading as the reporting systems differ and make it difficult to compute sufficiently robust rates at the population level. This allows trends over time to be observed, but does not risk misleading readers with estimates whose precision is open to question.

For the most part, it is difficult to compare the data provided by one country with that from another for several reasons: (a) different types of data sources from registries with different roles, purposes and nature; (b) underlying differences in the data-items collected; (c) different definitions of DRDs, even where based on ICD-10 codes there are varying approaches; (d) different criteria used to define cocaine-related DRDs; (e) varying lengths of time for which data

are available; and (f) delays in publishing data. It is possible to look at trends over time within a country/region, but even then consistency of data may vary over time in terms of geographical coverage (e.g. the UK SMR), quality of data reported, and level of detail recorded. These are issues common to previous EMCDDA data-collation exercises (e.g. Wirl, 2010).

Trends

During the 15-year period examined here (1998-2012), a considerable number of deaths was identified in the UK by both the GMRs (2728 death registrations) where cocaine was mentioned in the cause of death, and by the SMR (a minimum of 2907 deaths occurring) where cocaine was involved in the death. Such deaths accounted for about 5.23% of poisoning as an underlying cause in GMRs (using a broad definition of drug) and 10.43% of SMR deaths involving psychoactive substances in respect of UK DRDs. This constitutes a considerable health burden and a significant number of premature deaths that are largely preventable.

In Europe during the 2000s there was generally an increasing upward trend in cocaine-related deaths, followed by a decline in most countries (EMCDDA, 2011). However, the latest reports from NPSAD indicate a stabilisation in terms of cocaine deaths in 2011 (Corkery et al., 2014), but ~~an~~ increase~~s~~ between 2012 and 201~~3~~4 in England (Claridge & Goodair, 2015, 2017). The UK GMR death registrations in 2011-15 indicate a rise in such deaths (NISRA, 2016; NRS, 2016; ONS, 2016). The decrease after ~2008 is consistent with morbidity data in the UK (Mena et al., 2013; PHE, 2014). Although new presentations for treatment in England showed a continuous decline for primary crack use from 2007/8 to 2013/4, such notifications for cocaine

show a continuous rise from 2011/2 to 2013/4 (PHE, 2014). These patterns are replicated at a UK level (Burton et al., 2014). Close monitoring is still required.

The patterns in UK cocaine-related DRDs need to be set in a wider context. Cocaine-related mortality could also be related to a wider set of indicators, as done a number of years ago for the UK (Schifano and Corkery, 2006, 2008). Part of the recent decline apparent in some countries (EMCDDA, 2013a), may be related to a decline in cocaine purity and/or a shift to using alternative stimulants, including 'legal highs' (Corkery, 2012; EMCDDA, 2013b). The UK street price of cocaine powder seized by law enforcement agencies fell from £60 per gram in 2000 to £40 in 2008 and remaining at that level through to 2013 (Burton et al., 2014). However, the lower prices are probably due to the poorer quality of the cocaine. The mean purity of powder cocaine seized by the police in England & Wales fell from 33% in 2007 to 20% in 2009 before rising again to 38% in 2013; the purity of 'crack' cocaine is reported to have fallen during the same period from 52% to 27% in 2009 before rising to 36% in 2013 (Burton et al., 2014). 'Last year 'use of powder cocaine amongst 16–59 year-olds in England & Wales fell from 3.0% in 2008/9 to 1.9% in 2012/13 before rising to 2.3% in 2014/5 (Lader, 2015). The number of cocaine seizures in England & Wales peaked in 2008/9 and that for crack in 2007/8 since when both showed declining trends to 2012/3 with a stabilisation in 2013/4 (Dhani, 2014). The quantities seized fell for cocaine from 2003 to 2009/10, recovered slightly in 2011/2, fell back in 2012/3 but recovered in 2013/14 to a level similar to that in 2007/8; for crack it fell back in 2008/9 before rising in 2009/10, fell in 2011/2, rising again in 2012/3 and 2013/4.

There is now emerging evidence of a large problem of cocaine-related morbidity leading to hospitalisation and emergency visits (Mena et al., 2013). Chiefly involving males and young

patients (15-29 years old), they appear to follow patterns similar to those in cocaine DRDs in recent years. It has even been proposed that the fall in ecstasy and cocaine-related deaths in the United Kingdom since 2008 may have been as a result of users switching to 'legal highs' with the suggestion that this may have had an unintended harm reduction effect (Bird, 2010).

Demographic characteristics

The majority of cocaine-related deaths in 2005-9 reported to NPSAD occurred in the 20–24 to 45–49 years age-groups (minimum 15, maximum 81). Mean age at death for these cocaine cases is typically in the late 20s or early 30s, much younger than the mean commonly reported by the GMR using the EMCDDA Standard (41 years according to 2012 reporting) (i.e. all overdose deaths, accounted for mainly by opioid-related cases). Males accounted for 84% of cases, broadly in line with the general findings for UK deaths reported to the EMCDDA; this proportion is higher than the approximately 75% usually seen for 'typical' SMR cases in 2012. Half (36%) were unemployed compared to 52% of NPSAD deaths in 2012. Higher rates of last year powder cocaine use are higher in the groups with the lowest household income category of < £10k (typically those receiving social benefits/unemployment benefits) or at the other extreme those with a household income >= £50k (Home Office, 2013). A higher proportion of cases in the present study (54%) were living with someone else compared to 2012 NPSAD cases (44%). Cocaine fatalities (82%) had a considerably higher occurrence of having a history of drug use than NPSAD cases in 2012 (67%). A wider range of ethnicities died from cocaine use during this period (88% White) compared to those recorded for NPSAD cases in general in 2012 (97% White) (Corkery et al., 2014).

Characteristics of deaths

The vast majority (88%) of SMR deaths where cocaine was involved in the death were regarded as poisonings or overdoses involving this substance and/or its metabolites; similar to that found for NPSAD cases in 2012 (Corkery et al., 2014). Some 13% of cases had a reported pre-existing cardiovascular/cardiopulmonary condition, with 22% developing primarily cardiac and pulmonary medical conditions, reflecting the dangers already known about cocaine (see Table 7). Regular cocaine use can increase systolic blood pressure, aortic stiffness and left ventricular mass; these are well-recognised as risk factors for premature cardio-vascular events (Kozor et al., 2014).

More individuals experimenting with the drug is a cause for serious concern, especially those with underlying coronary artery disease as it increases double product (heart rate x systolic blood pressure) and myocardial oxygen demand (Howard et al., 1985). Of note in this context is coronary atherosclerosis - particularly of the left anterior descending coronary artery (Darke et al., 2006); this is because a higher proportion of the minority of subjects at risk of acute cocaine medical sequelae and fatalities (genetic causes, such as fully or partially expressed congenital long QT syndrome, may play a role; Karch, 2005) will be more likely to be self-administering the compound (Webb et al., 2003). Furthermore, greater availability of cocaine formulations means that some consumers may find it easier to enter a chronic consumption pattern. According to Karch (2005), most deaths occur after prolonged drug use, which can induce a series of changes at the molecular, cellular, and tissue levels. Potentially lethal myocardial alterations include hypertrophy, fibrosis, and microangiopathy and all of these changes favour sudden death, possibly through hypertension, arrhythmias, and cardiac infarction (Knuepfer, 2003;

Vasica and Tennant, 2002). Darke et al. (2005) found cardiac pathology in 57% of 146 cocaine-related fatalities, most commonly coronary artery atherosclerosis (39%) and cardiac hypertrophy (14%); cerebrovascular pathology was noted in 22% of cases.

<Table 7 about here>

Both the GMR and SMR UK data show that polydrug abuse ingestion was involved in most cocaine-related fatalities. This closely mirrors an earlier study looking at amphetamine/ methamphetamine and ecstasy deaths reported to NPSAD, where ecstasy fatal ingestion seemed to be most typically identified together with cocaine (Schifano et al., 2010), and both drugs are frequently associated with the recreational scene (Winstock and Schifano, 2009). Co-occurrence of two stimulants (i.e. MDMA together with cocaine) might increase, in a synergic way, both the dopaminergic and serotonergic stimulation, so that the 'serotonin syndrome' is more likely to occur (Schifano, 2004). Cocaine/amphetamine users have an increased risk of death (Arendt et al., 2011).

Contributory clinical factors described here at post mortem in cocaine fatalities were overall consistent with the existing literature, often anecdotal in nature, and reflect a number of issues, including: the sympathomimetic action of cocaine (Liaudet et al., 2014); ~~the~~ possible idiosyncratic toxic reactions to this drug (Bromley and Hayward, 1988; Chakko and Myerburg, 1995); and ~~the~~ risk-taking behaviour by~~of~~ cocaine misusers (Pavarin et al., 2011). These findings are similar to those found in respect of ecstasy and amphetamine/methamphetamine fatalities (Schifano et al., 2010).

CNS suppressants such as opiates (especially heroin/morphine), drugs for anxiety/insomnia~~hypnotics/sedatives~~ (principally benzodiazepines) and alcohol contribute significantly to UK cocaine-related deaths – whether only with cocaine or with cocaine and other drugs. Other medications and 'recreational' drugs contribute less to cocaine deaths – but it is important to note the contribution played by other stimulants, i.e. ecstasy and amphetamines. In 22.4% of all NPSAD deaths in which cocaine was implicated in 2005-9, it was the only drug implicated.

For NPSAD overall in 1998-2012, there were 11.4 times more PM cases with cocaine and other substances than cases with only cocaine mentioned; the ratio for such 'mentions' in the cause of death field was 4.7. The overall proportion of sole cocaine 'mentions' in the cause of death during the period 1998-2012 was 17.5% (range 9.6-25.7%). This finding was echoed by the PM toxicology findings, where the overall proportion of sole cocaine findings in PM toxicology during the period 1998-2012 was 8.1% (range 3.0-19.6%). These results reflect a trend towards poly-substance abuse; an average of 3.37 substances was found in PM toxicology in 2005-9.

The number of cases where cocaine was found in PM toxicology was 44.5 % (n=4200) higher than the number where it was implicated in the cause of death (n=2907). The ratio for 1998-2012 was 1.44:1.

The clearest feature is that opiates/opioids are involved in most cases (58%), often without other substances. This dominant presence of opiates/opioids in cocaine-related DRDs (mostly defined here as poisoning/overdoses) mirrors wider patterns evident in European and UK DRDs (Burton et al., 2014; EMCDDA, 2015). The large proportion of cocaine-related deaths in the

present study involving heroin, methadone or other opioids also echoes that in respect of our earlier study of amphetamine/methamphetamine users (Schifano et al., 2010). These are drugs with high levels of toxicity in overdose and typically associated with the 'hard core' addiction scene (Ghodse et al., 2008). This suggests that many cocaine users are problematic and poly-substance users; both factors increasing the risk of overdose/poisoning and of death.

Alcohol (either alone or together with other drugs) was identified in combination with cocaine in about 21% of NPSAD cases in 2005-9. Cocaine and ethanol are commonly consumed at the same time (Schifano, 2001). Cocaine is transesterified by liver esterases to cocaethylene, which has cocaine-like pharmacologic properties, in the presence of ethanol (Dean et al., 1991). Both ethanol and cocaethylene reduce mean cocaine clearance by 47% and 26%, respectively (Parker et al., 1996). The effect of cocaine is therefore prolonged and the 'comedown' following cocaine is diminished (Schifano and Corkery, 2008).

Non-poisoning/overdose cases

Poisonings and somatic deaths overlap so it can be difficult to distinguish between them. For most GMRs, including the UK, the mode of use or route of administration of cocaine is not known/recorded. The UK SMR (NPSAD) does record such information when available, but is dependent on the quality of data submitted. These factors may lead to under-identification of somatic cases associated with cocaine use, as the link would only be apparent from evidential information or intelligence.

In the UK SMR most cocaine-related cases (87%) were ascribed to underlying cause in 2005-9. 'General medical condition' appears to play a large contribution to non-overdose cases, about one-third in the UK. This category encompasses a whole range of underlying causes of death which might merit closer examination in the future using a finer-grained approach. Some non-overdose cases due to cocaine are recorded. These are even more likely than poisoning to be underestimated, e.g. excited delirium, road traffic accidents (RTAs). Deaths involving accidental injury and RTAs also feature as do suicides (often by hanging) in most countries, especially in the UK.

Mental and behavioural disorders play a role in UK deaths. For example, in 2011-2 the mortality rate for service users in England recorded in the Mental Health Minimum Dataset was 4008 deaths per 100,000 compared to 1122 deaths per 100,000 in the general population - 3.6 times higher (HSCIC, 2013). Premature mortality attributable to illicit drug dependence was calculated as Years of Life Lost (YLL) based on cause of death estimates by the Global Burden of Disease (GBD) team for the year 2010 (Degenhardt et al., 2013). An estimate of 25,000 YLL due to cocaine dependence was indicated, contributing 5.5% of the drug dependence considered. This equates to 4290 deaths worldwide each year (i.e. 5.5% of 78,000 deaths p.a. due to illicit drug disorders). In the present study, 4% of cocaine poisoning deaths in 2005-9 reported to the UK SMR were due to intoxication, dependence, etc. Suicide by regular users of cocaine was found by the GBD team to be a significant contributor to the illicit drug burden. In addition, cocaine dependence accounted for 6.9 million cases of mental and substance use disorders worldwide in 2010 (Whiteford et al., 2013). In Western Europe there were an estimated 640,700 cases with a further 62,000 in Central Europe (Degenhardt et al., 2014).

At-risk groups

The data from the UK SMR (see Tables 5, 6 and 7) suggest the possibility of five categories of cocaine users at greater risk of dying:

(a) those using cocaine in the context of opioid use, especially heroin and methadone (Pavarin, 2013; de la Fuente et al., 2014);

(b) those using cocaine with alcohol, as in the 'champagne' (Shapiro, 2002; Santos et al., 2012) style or mode (Roe and Man, 2006);

(c) those using cocaine in the context of psychiatric problems or experiencing psychiatric problems consequent to cocaine misuse/abuse (Arendt et al., 2011; Addy et al., 2012) (instances of psychiatric medications, i.e. drugs for depression~~antidepressants~~ and/or drugs for psychosis~~antipsychotics~~ implicated in death);

(d) those consuming cocaine in the context of recreational drug use, including other stimulants (amphetamine, ecstasy), GHB/GBL, ketamine and Novel Psychoactive Substances, e.g. in night clubs, discos (Roe and Man, 2006; Home Office, 2012; Corkery et al., 2015); and

(e) those with cardiovascular/remaining medical conditions (Cregler, 1989; Gray, 1993; Pavarin et al., 2011).

Some of these groups are redolent of those identified/described in the British Crime Survey (Roe and Man, 2006). A limitation of the profile of users is that it is based on deaths only up to 2009. If the period was extended not only would there be more cases on which to draw conclusions but also one would be able to see if any of the characteristics changed over time, especially in response to the emergence of NPS. In this study period (2005-9) the only NPS class emerging was piperazines. Since then, other stimulants such as synthetic cathinones and cannabinoids have appeared (Schifano et al., 2015).

Toxicological analysis

There may be some types of death where toxicological analysis may not be undertaken or the role of psychoactive substances is underplayed because of the main cause of death e.g. assaults, suicides (particularly using violent means such as hanging), or accidents (RTAs, drowning, accidental injury). Such cases may therefore not be recorded as drug-related let alone as cocaine-related. Thus, the data provided here are likely to underestimate the presence of and/or involvement of cocaine in these kinds of unnatural death.

EMCDDA DRD experts consider that guidance is needed on interpretation of post mortem toxicology levels to define overdoses/poisonings (Corkery, 2012). There are wide variations in levels considered be toxic/fatal/lethal, especially when considering post mortem redistribution. These levels can be affected by poly-substance use and metabolism. It is important to know fatal levels for sole cocaine deaths. Bertol et al. (2008) suggest that it is not generally possible to correlate specific blood/tissue concentrations with toxicity. However, some guidance on post mortem toxicology levels and help in the operationalisation of these aspects is available (Lahti

et al., 2009; Stephens et al., 2004). Equally important is the need to identify the effect of poly-substance use on what should be regarded as fatal levels. New challenges in this area are posed in monitoring and understanding such deaths because of the growing trend towards using multiple stimulants.

Cutting agents

Consideration needs to be taken of the potential contribution to cocaine-related deaths played by common cutting-agents found in powder cocaine – and to a lesser extent in 'crack'. Cutting agents include both pharmacologically inactive substances with a similar appearance i.e. diluents (e.g. sugars such as mannitol) and adulterants which are pharmacologically active components that may alter a drug's properties. It has been suggested that the addition of adulterants to cocaine is to meet increased demand for the drug, they are cheaper alternatives to cocaine, and they can be used to increase profits by diluting the final product (Brunt et al., 2009). Cocaine derivatives such as benzocaine, lidocaine/lignocaine, procaine, as well as caffeine, are common examples.

Over the past two decades the following adulterants, which are 'per se' associated with levels of toxicity (Pawlik et al., 2015), have been found in cocaine seized by law enforcement agencies and/or PM toxicological assays in the UK and Western Europe: atropine, benzocaine, caffeine, diltiazem, ephedrine, hydroxyzine, levamisole, lidocaine/lignocaine, paracetamol, phenacetin, procaine (King, 1997; Brunt et al., 2009; Evrard et al., 2010; Schneider and Meys, 2011). There appear to have been increases in caffeine, diltiazem, hydroxyzine and levamisole since 2007 but a decrease in lidocaine over the years. The diversity of adulterants in cocaine has increased

considerably (Brunt et al., 2009), and up to 14 may be found in one sample (Schneider and Meys, 2011). The commonest adulterants in UK seizures in during 2014 were (LGC, 2015): powder cocaine – benzocaine, caffeine, creatine, diltiazem, levamisole, lignocaine, paracetamol and phenacetin; crack – benzocaine, caffeine, levamisole and phenacetin.

Generally speaking, adulterated cocaine is more likely to give rise to reported adverse effects than purer forms (Brunt et al., 2009). However, Brunt et al. (2009) suggest that such reports are more likely in relation to diltiazem, hydroxyzine and phenacetin, but not caffeine, levamisole, lidocaine/lignocaine and procaine. The possibility of interactions between adulterants and cocaine is not well researched. Additional concerns are that: often durations of exposure are unknown (Brunt et al., 2009; Evrard et al., 2010); users are unable to detect specific adulterants (Evrard et al., 2010); the variable purity level and the wide range of adulterants can lead to unpredictable clinical effects (Evrard et al., 2010); and many of these adulterants are prescribed for oral ingestion in therapeutic treatment but pharmacokinetic properties such as absorption, bio-availability, distribution, metabolism and kinetics may be affected by other administration routes (Brunt et al., 2009; Pawlik et al., 2015). If cocaine is insufflated or smoked the adulterants will also be incorporated into the lung initially (Pawlik and Mahler, 2013), and may result in lung damage or disease (Hollinger, 1993; Kehrer and Kacew, 1985). Lidocaine, for example, may cause pulmonary parenchymal damage, and levamisole's metabolite – aminorex – causes pulmonary hypertension (Hollinger, 1993).

Limitations

Detailed demographic and other information are not published by the UK GMRs in respect of specific substances. Only the Scottish GMR has access to toxicological information, and even that is very limited. However, in recent years the Scottish DRD database has linked GMR data with information regarding toxicology and pathology and publishes some more detailed analysis (Barnsdale et al., 2016). A similar approach could be used to advantage in other parts of the UK.

Although the UK SMR results suggest that most cocaine-related deaths are also opiate/opioid-related and/or polydrug poisoning cases, it is likely that some cocaine-related fatalities will be missed by the DRD Key Indicator data based on UK GMR data. This is because UK GMRs do not typically have access to toxicological information and up to 12% of all drug poisonings fatalities in the UK recorded by the GMRs are recorded as multiple/substances intoxications/overdoses without specific substances being recorded on the death certificate (ONS, 2014).

Limited data were available when the original study was conducted. Looking at SMR data over a longer period would provide a larger dataset for analysis and facilitate an examination of trends in characteristics of both individuals experiencing cocaine-related fatalities and also of the mechanisms/causes of death an any change in contributing factors, especially with regard to the consumption of other psychoactive substances (including alcohol) and the adulterants used as cutting agents. Also an examination of mortality trends splitting cases into ones involving opiates/opioids vs. other substances may reveal other issues of interest.

Conclusions

GMR information provides some indications of long-term trends and possible numbers of cases of deaths related to cocaine, as does UK SMR data. The latter is beneficial in providing a more in-depth understanding of the characteristics of decedents and the nature of their deaths. As with other projects looking at DRDs, the EMCDDA project faced problems arising from the different nature, purposes, roles and type of data recorded by individual registries, especially SMRs. The level of detail, use or not of ICD codes and other information to identify relevant cases, as well as varying selection criteria are impacted by those differences. In turn, this affected the quality and type of data submitted. However, this project gives pointers for where further refinement could be targeted. Guidance is needed on the PM toxicology levels to define overdoses/poisonings. There are wide variations in levels considered toxic/fatal/lethal. These levels can be affected by poly-substance use and metabolism in terms of blood levels. It is important to know levels for sole cocaine and poly-substance deaths. The provision of such guidance across the EU and UK may help improve case-identification both prospectively and in any future retrospective data analyses.

This analysis of fatalities that did not arise through overdose suggests that it would be valuable to examine more closely those cases ascribed to 'general medical conditions', 'cardiovascular and other issues', etc. The scientific medical literature is increasingly featuring small-scale case-study or anecdotal reports of conditions associated with the acute and chronic use of cocaine. Mena et al. (2013) found a considerable increase in the numbers of cocaine-related hospital episodes and emergency admissions since the end of the 1990s in the countries that reported the highest number of episodes, numbers peaking around 2007/8 in Spain and the UK. This underlines the importance of seeking a more accurate picture of the numerical extent of such

conditions and a fuller understanding of what conditions and diseases are caused, and how, by cocaine use. Other areas that could also be examined in the future include: the role of cocaine in deaths involving accidental injuries, road traffic accidents, and suicides - especially by hanging. There is anecdotal material, including from the UK, to suggest that stimulants (such as cocaine, MDMA, amphetamine, and more recently methcathinones) are often consumed by the decedents in such cases; published literature on these aspects is very limited, e.g. Rajs & Fugelstad (1999), Oyefeso et al. (2006),

Further research is needed on the clinical implications of cocaine misuse in the context of polydrug intoxication – especially with regard to possible changes over time in the co-ingestion/administration of opioids on the one hand and stimulants on the other, with deaths where cocaine was directly related to death and other cases where it was just found at post mortem being compared, and should also specifically address the issue of possible individual psychobiological/genetic vulnerability to deaths caused by cocaine (Schifano and Corkery, 2008). The role of adulterants in cocaine in contributing to death also warrants further investigation.

In conclusion, cocaine-related DRDs have become an important feature of drug-related mortality in the UK and Europe generally - perhaps accounting for more than 1000 deaths each year. These are likely to continue to be so in the future, due to the large number of chronic and problematic users. There are at least 42,000 cocaine/crack users seeking treatment in the UK in recent years (personal communications from Public Health England on 16 January and 25 February 2015 to lead author; ISD Scotland 2014; DHSSPSNI, 2014; Welsh Government & NHS Wales, 2014). Furthermore, we have noted in the UK increasing quantities of cocaine

powder and crack being seized by law enforcement agencies, rising purity levels for street cocaine and crack, and increasing presentations for treatment by primary cocaine users. All of these would suggest the potential for continuing or rising numbers of deaths due to cocaine use. Indeed, there are indications that cocaine-related deaths across the UK are on the increase again (NISRA, 2016; NRS, 2016; ONS, 2016). It is necessary to understand the nature and extent of this phenomenon. Some core commonalities have been observed in respect of the UK, but more information is needed, especially since they accounted for 5% of all UK poisoning deaths registered in the period 1998-2012, an average of 174 deaths each year. The data and information presented in this paper and the EMCDDA project (Corkery, 2012) provides the first insights into the nature and possible extent of the phenomenon of cocaine-related DRDs in the UK and Europe.

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Conflicts of interest

JC acted as the Drug-related Deaths expert for the United Kingdom's Focal Point on Drugs (UKFP) from 2000 to 2015, and continues to provide advice. CG and HC run the National Programme on Substance Abuse Deaths (NPSAD), and JC and FS were formerly part of NPSAD. The views expressed here reflect only the authors' views and not necessarily those of the UKFP or the EMCDDA.

Declaration

This work has not been previously published and has not been submitted for publication elsewhere. Publication is approved by all authors and the responsible authorities where the

research was undertaken. If accepted, the paper will not be published elsewhere in the same form, in English or in any other language, without the written consent of the copyright holder.

Ethical approval

The Central Office for Research Ethics Committees (COREC), National Patient Safety Agency confirmed in writing (February 2006) that the NPSAD Programme does not require NHS REC review as the subjects of the research are deceased. The GMR data are in the public domain.

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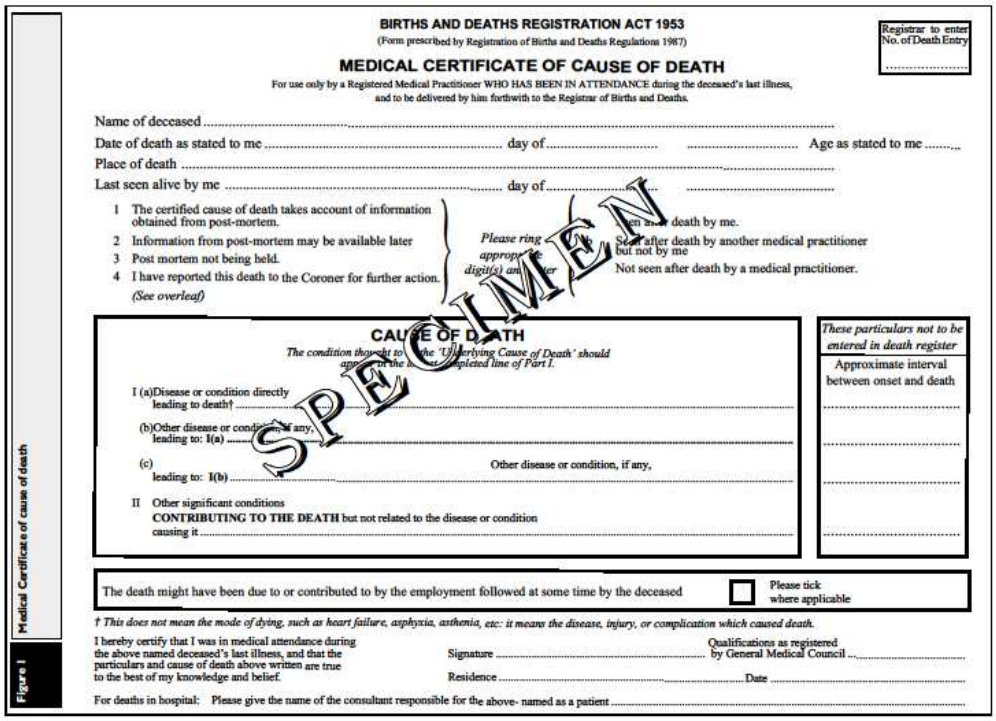
Figure 1: Medical Certificate of Death used in England and Wales



BIRTHS AND DEATHS REGISTRATION ACT 1953

(Form prescribed by Registration of Births and Deaths Regulations 1987)

Registrar to enter No. of Death Entry .....

MEDICAL CERTIFICATE OF CAUSE OF DEATH

For use only by a Registered Medical Practitioner WHO HAS BEEN IN ATTENDANCE during the deceased's last illness, and to be delivered by him forthwith to the Registrar of Births and Deaths.

Name of deceased .....

Date of death as stated to me ..... day of .... Age as stated to me .....

Place of death .....

Last seen alive by me ..... day of ....

1 The certified cause of death takes account of information obtained from post-mortem.
2 Information from post-mortem may be available later
3 Post mortem not being held.
4 I have reported this death to the Coroner for further action.
(See overleaf)

Please ring appropriate digit(s) and letter

Seen after death by me.
Seen after death by another medical practitioner but not by me
Not seen after death by a medical practitioner.

SPECIMEN

CAUSE OF DEATH

The condition thought to be the 'Underlying Cause of Death' should appear in the last completed line of Part I.

I (a) Disease or condition directly leading to death† .....
(b) Other disease or condition, if any, leading to: I(a) .....
(c) Other disease or condition, if any, leading to: I(b) .....
II Other significant conditions CONTRIBUTING TO THE DEATH but not related to the disease or condition causing it .....

These particulars not to be entered in death register
Approximate interval between onset and death

The death might have been due to or contributed to by the employment followed at some time by the deceased ☐ Please tick where applicable

† This does not mean the mode of dying, such as heart failure, asphyxia, asthenia, etc: it means the disease, injury, or complication which caused death.

I hereby certify that I was in medical attendance during the above named deceased's last illness, and that the particulars and cause of death above written are true to the best of my knowledge and belief.

Signature ..... Qualifications as registered by General Medical Council .....
Residence ..... Date .....

For deaths in hospital: Please give the name of the consultant responsible for the above- named as a patient .....

Medical Certificate of cause of death

Figure 1

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Source: Rooney and Smith, 2000. Reproduced with permission.

Figure 2: Trends in UK cocaine-related DRDs (any mention): actual numbers in 1998–2012, based on SMR and GMR and reported for cocaine mentioned in the cause of death (COD), or identified in post mortem (PM)

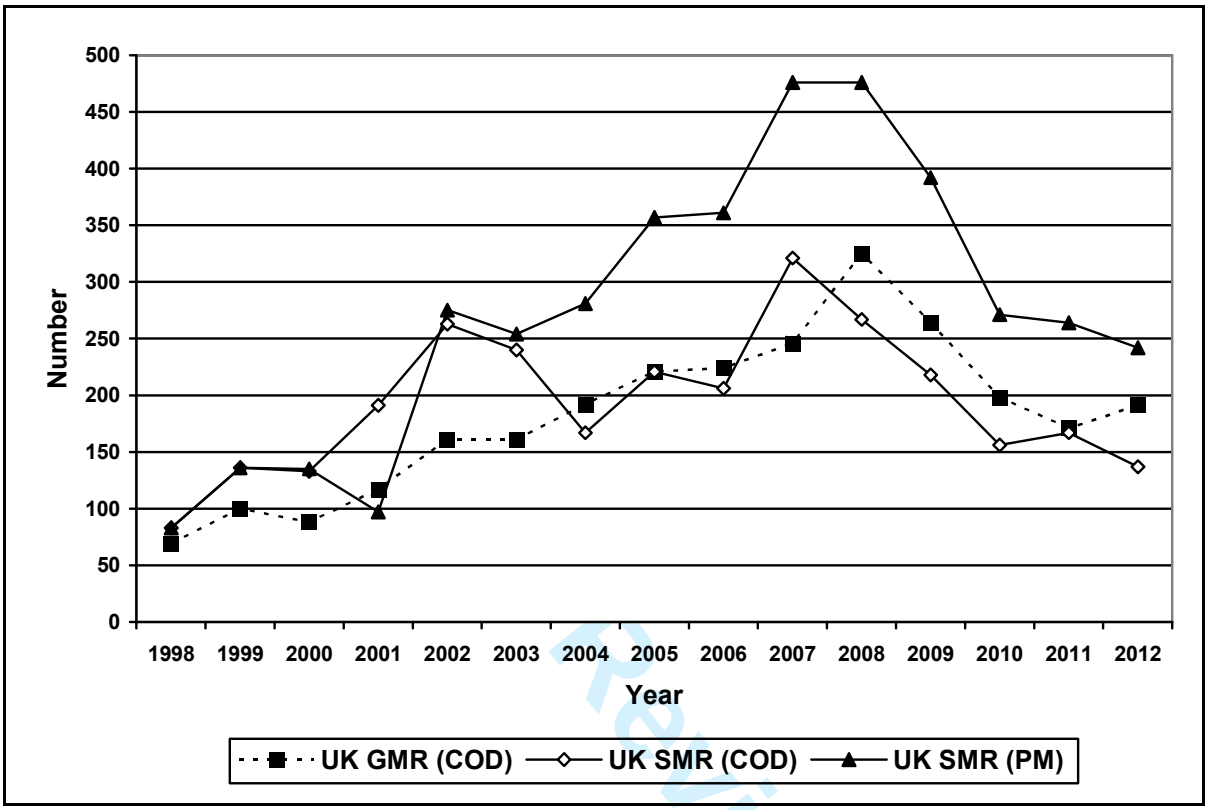
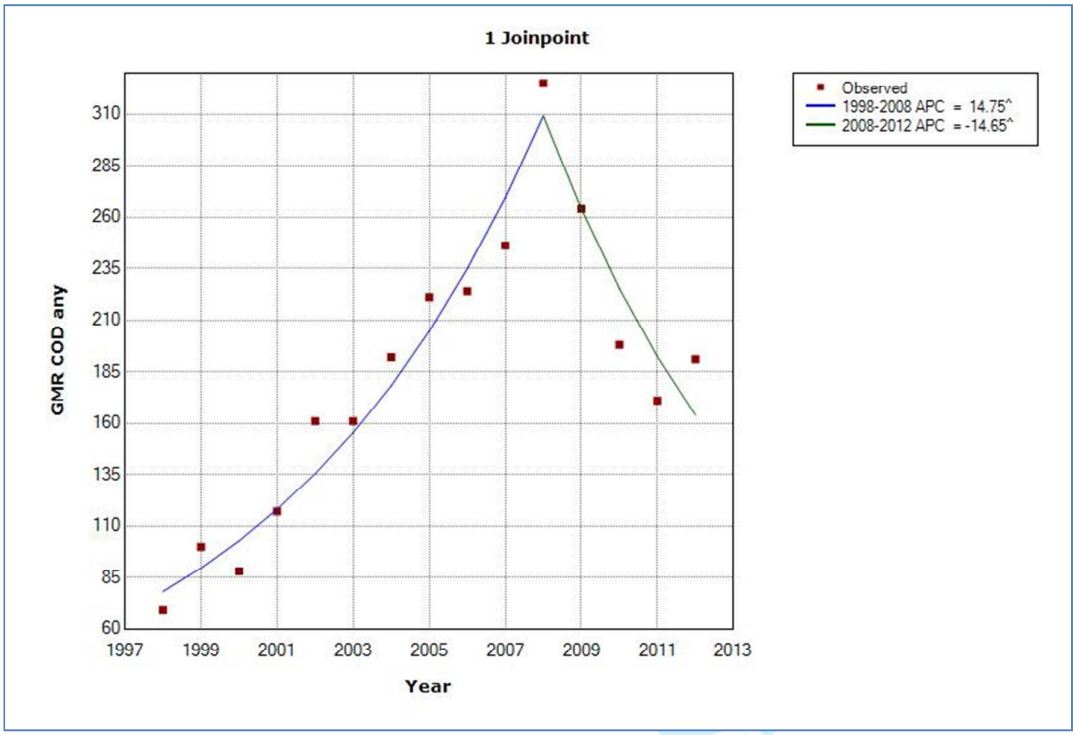


Figure 3: Results of Joinpoint analyses for UK cocaine-related death trends 1998-2012

GMR Cause of Death Any Mention



Graph | Data | Model Estimates | Trends | Model Selection

Estimated Joinpoints

Joinpoint	Estimate	Lower CI	Upper CI
1	2008	2006	2009

Annual Percent Change (APC)

Segment	Lower Endpoint	Upper Endpoint	APC	Lower CI	Upper CI	Test Statistic	P-Value
1	1998	2008	14.7^	11.4	18.2	10.4	0.0
2	2008	2012	-14.6^	-24.3	-3.8	-2.9	0.0

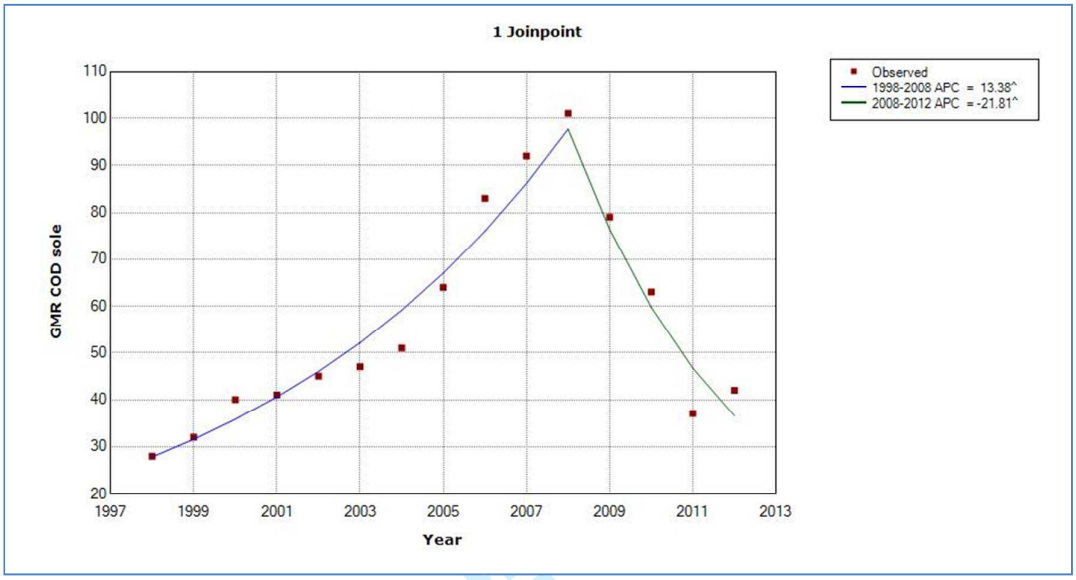
^ The Annual Percent Change (APC) is significantly different from zero at alpha = 0.05

Average Annual Percent Change (AAPC)

Cohort	Range	Lower Endpoint	Upper Endpoint	AAPC	Lower CI	Upper CI	Test Statistic	P-Value
	Full Range	1998	2012	5.4^	1.8	9.2	2.9	0.0

^ The Average Annual Percent Change (AAPC) is significantly different from zero at alpha = 0.05. Parametric method used.

GMR Cause of Death Sole Mention



Graph | Data | Model Estimates | Trends | Model Selection

Estimated Joinpoints

Joinpoint	Estimate	Lower CI	Upper CI
1	2008	2007	2009

Annual Percent Change (APC)

Segment	Lower Endpoint	Upper Endpoint	APC	Lower CI	Upper CI	Test Statistic	P-Value
1	1998	2008	13.4^	10.2	16.7	9.7	0.0
2	2008	2012	-21.8^	-30.4	-12.1	-4.7	0.0

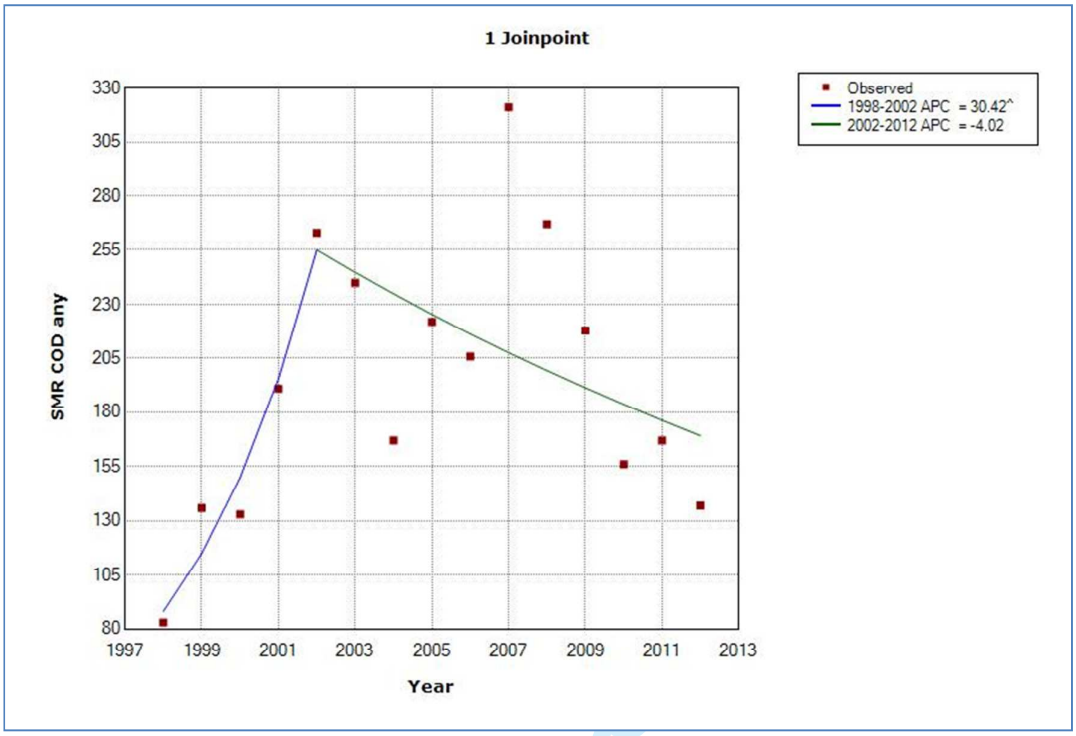
^ The Annual Percent Change (APC) is significantly different from zero at alpha = 0.05

Average Annual Percent Change (AAPC)

Cohort	Range	Lower Endpoint	Upper Endpoint	AAPC	Lower CI	Upper CI	Test Statistic	P-Value
	Full Range	1998	2012	2.0	-1.5	5.5	1.1	0.3

^ The Average Annual Percent Change (AAPC) is significantly different from zero at alpha = 0.05. Parametric method used.

SMR Cause of Death Any Mention



Graph | Data | Model Estimates | Trends | Model Selection

Estimated Joinpoints

Joinpoint	Estimate	Lower CI	Upper CI
1	2002	2000	2009

Annual Percent Change (APC)

Segment	Lower Endpoint	Upper Endpoint	APC	Lower CI	Upper CI	Test Statistic	P-Value
1	1998	2002	30.4^	3.7	64.1	2.6	0.0
2	2002	2012	-4.0	-9.3	1.6	-1.6	0.1

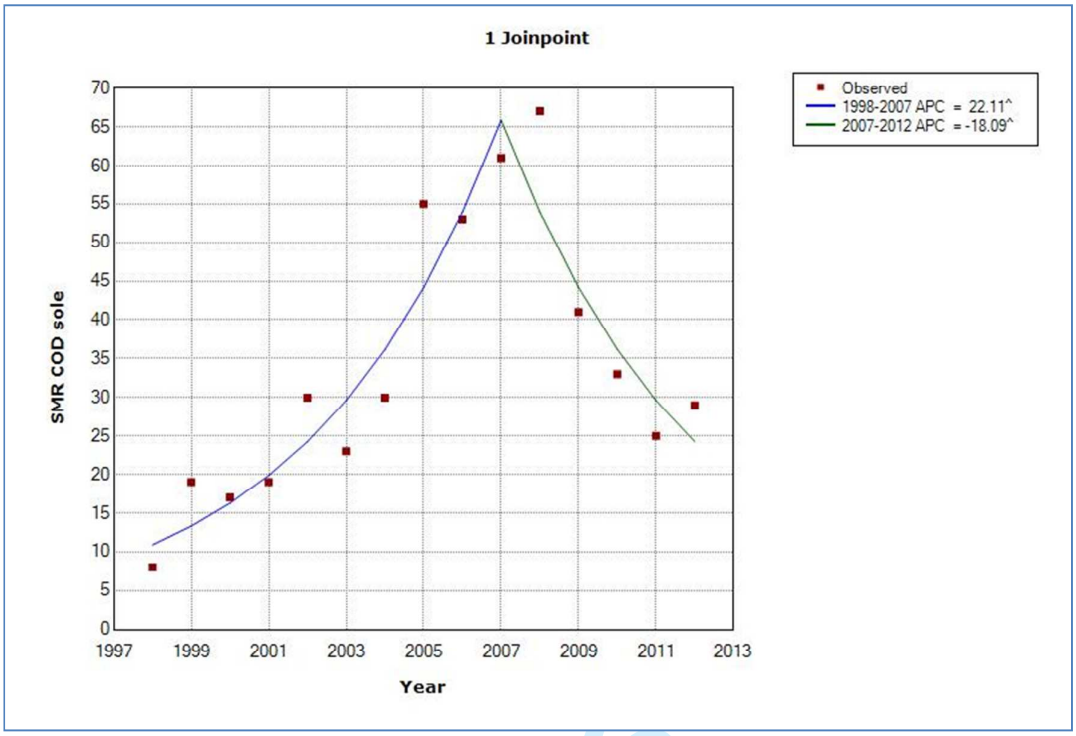
^ The Annual Percent Change (APC) is significantly different from zero at alpha = 0.05

Average Annual Percent Change (AAPC)

Cohort	Range	Lower Endpoint	Upper Endpoint	AAPC	Lower CI	Upper CI	Test Statistic	P-Value

^ The Average Annual Percent Change (AAPC) is significantly different from zero at alpha = 0.05. Parametric method used.

SMR Cause of Death Sole Mention



Graph | Data | Model Estimates | Trends | Model Selection

Estimated Joinpoints

Joinpoint	Estimate	Lower CI	Upper CI
1	2007	2005	2009

Annual Percent Change (APC)

Segment	Lower Endpoint	Upper Endpoint	APC	Lower CI	Upper CI	Test Statistic	P-Value
1	1998	2007	22.1^	14.2	30.5	6.7	0.0
2	2007	2012	-18.1^	-30.4	-3.6	-2.7	0.0

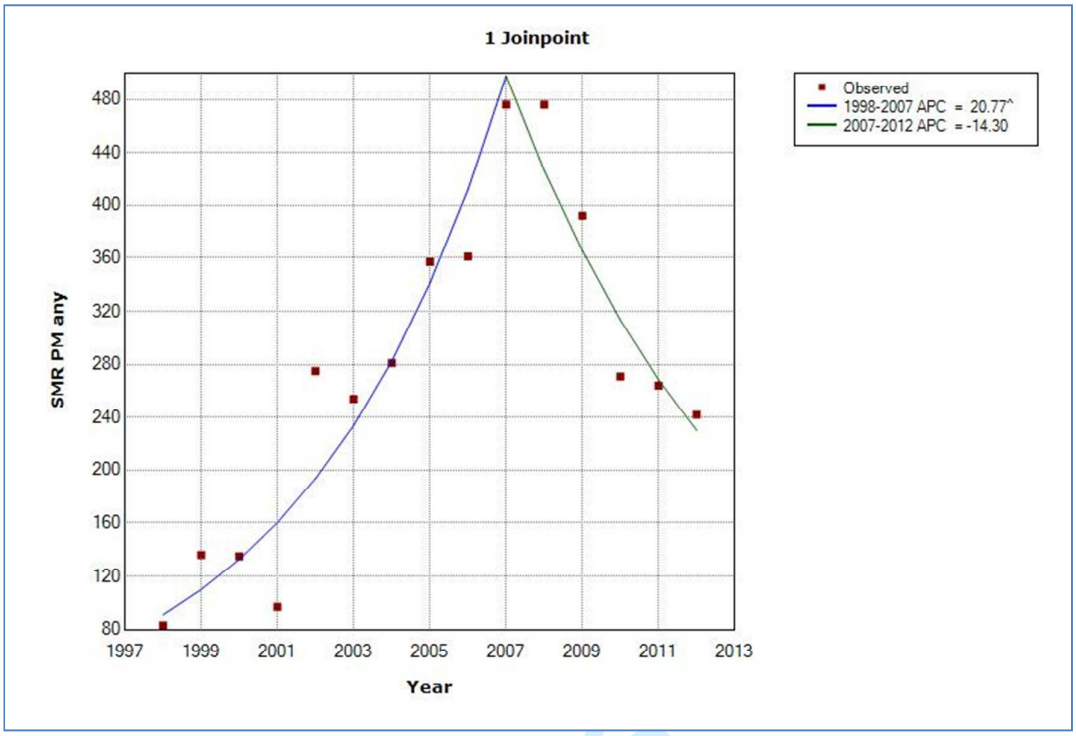
^ The Annual Percent Change (APC) is significantly different from zero at alpha = 0.05

Average Annual Percent Change (AAPC)

Cohort	Range	Lower Endpoint	Upper Endpoint	AAPC	Lower CI	Upper CI	Test Statistic	P-Value

^ The Average Annual Percent Change (AAPC) is significantly different from zero at alpha = 0.05. Parametric method used.

SMR Post Mortem Toxicology Any Mention



Graph | Data | Model Estimates | Trends | Model Selection

Estimated Joinpoints

Joinpoint	Estimate	Lower CI	Upper CI
1	2007	2005	2009

Annual Percent Change (APC)

Segment	Lower Endpoint	Upper Endpoint	APC	Lower CI	Upper CI	Test Statistic	P-Value
1	1998	2007	20.8^	13.3	28.7	6.6	0.0
2	2007	2012	-14.3	-26.7	0.2	-2.2	0.1

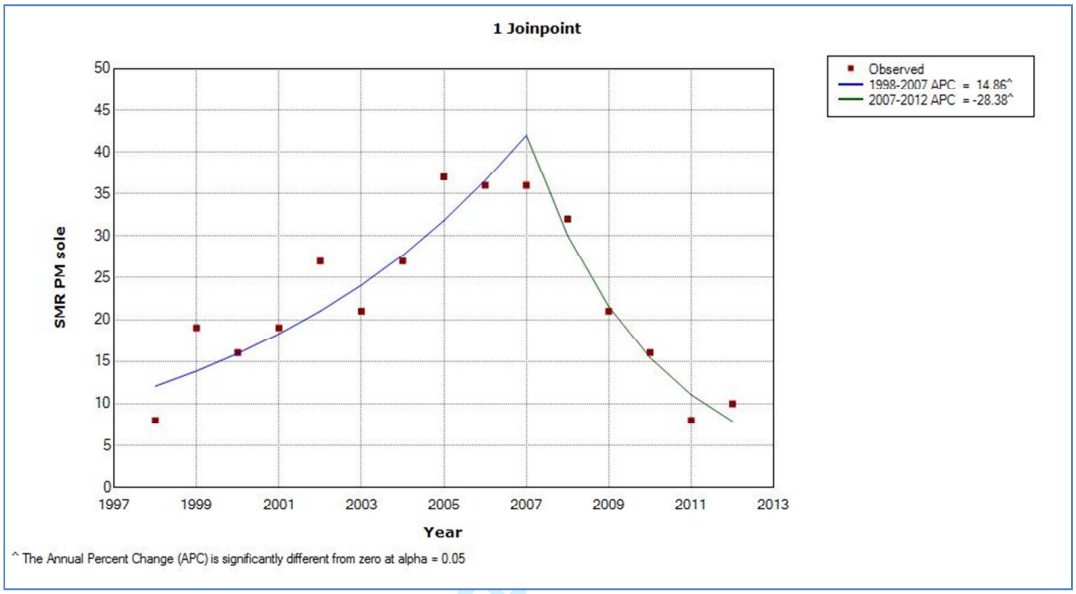
^ The Annual Percent Change (APC) is significantly different from zero at alpha = 0.05

Average Annual Percent Change (AAPC)

Cohort	Range	Lower Endpoint	Upper Endpoint	AAPC	Lower CI	Upper CI	Test Statistic	P-Value

^ The Average Annual Percent Change (AAPC) is significantly different from zero at alpha = 0.05. Parametric method used.

SMR Post Mortem Toxicology Sole Mention



Graph | Data | Model Estimates | Trends | Model Selection

Estimated Joinpoints

Joinpoint	Estimate	Lower CI	Upper CI
1	2007	2004	2009

Annual Percent Change (APC)

Segment	Lower Endpoint	Upper Endpoint	APC	Lower CI	Upper CI	Test Statistic	P-Value
1	1998	2007	14.9^	7.5	22.7	4.7	0.0
2	2007	2012	-28.4^	-39.1	-15.8	-4.6	0.0

^ The Annual Percent Change (APC) is significantly different from zero at alpha = 0.05

Average Annual Percent Change (AAPC)

Cohort	Range	Lower Endpoint	Upper Endpoint	AAPC	Lower CI	Upper CI	Test Statistic	P-Value
	Full Range	1998	2012	-3.0	-8.9	3.3	-0.9	0.3

^ The Average Annual Percent Change (AAPC) is significantly different from zero at alpha = 0.05. Parametric method used.

Table 1: Cocaine-related deaths recorded by UK GMRs and SMR, 1998–2012

Case definition	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
GMR cause of death																
Any mention	69	100	88	117	161	161	192	221	224	246	325	264	198	171	191	2728
Of which as sole substance	28	32	40	41	45	47	51	64	83	92	101	79	63	37	42	845
Ratio of any/sole	2.46	3.13	2.20	2.85	3.58	3.43	3.76	3.45	2.70	2.67	3.22	3.34	3.14	4.62	4.55	3.23
Sole as proportion of any (%)	40.6	32.0	45.5	35.0	28.0	29.2	26.6	29.0	37.1	37.4	31.1	29.9	31.8	21.6	22.0	31.0
SMR cause of death																
Any mention	83	136	133	191	263	240	167	222	206	321	267	218	156	167	137	2907
Of which as sole substance	8	19	17	19	30	23	30	55	53	61	67	41	33	25	29	510
Ratio of any/sole	10.38	7.16	7.82	10.05	8.77	10.43	5.57	4.04	3.89	5.26	3.99	5.32	4.73	6.68	4.72	5.70
Sole as proportion of any (%)	9.6	14.0	12.8	9.9	11.4	9.6	18.0	24.8	25.7	19.0	25.1	18.8	21.2	15.0	21.2	17.5
SMR post mortem mentions																
Any mention	83	136	135	97	275	254	281	357	361	476	476	392	271	264	242	4100
Of which as sole substance	8	19	16	19	27	21	27	37	36	36	32	21	16	8	10	333
Ratio of any/sole	10.38	7.16	8.44	10.37	10.19	12.10	10.41	9.65	10.03	13.60	14.88	18.67	16.94	33.00	24.20	12.31
Sole as proportion of any (%)	9.6	14.0	11.9	19.6	9.8	8.3	9.6	10.4	10.0	7.6	6.7	5.4	5.9	3.0	4.1	8.1

Notes: GMR is year of registration; SMR is year of death

Table 2: Summary of Joinpoint analyses for UK cocaine-related deaths, 1998-2012

Dataset	Period 1	APC 1	Period 2	APC 2	P value	Significant at 0.05 level
GMR Cause of Death						
Any	1998-2008	+14.75*	2008-2012	-14.65*	0.3128889	Yes
Sole	1998-2008	+13.38*	2008-2012	-21.81*	0.4004444	Yes
SMR Cause of Death						
Any	1998-2002	+30.42*	2002-2012	-4.02	0.0857778	Yes
Sole	1998-2007	+22.11*	2007-2012	-18.09*	0.8853333	Yes
SMR Post Mortem toxicology						
Any	1998-2007	+20.77*	2007-2012	-14.30*	0.9742222	Yes
Sole	1998-2007	+14.90*	2007-2012	-28.40*	0.4102222	Yes
Notes: APC = Annual Percent Change; * = p <0.05						

Table 3: Demographic characteristics of UK SMR cocaine-related DRDs 2005-9

Characteristic	Category	Sole		Any	
		Number	%	Number	%
Total		277	100.0	1234	100.0
Gender	Male	241	87.0	1042	84.4
	Female	36	13.0	192	15.6
Age-group (years)	< 15	0	0.0	0	0.0
	15-24	40	14.4	183	14.8
	25-34	105	37.9	506	41.0
	35-44	97	35.0	394	31.9
	45-54	28	10.1	127	10.3
	55-64	6	2.2	21	1.7
	65 & over	1	0.4	3	0.2
Ethnicity	White	187	67.5	856	69.4
	Black	26	9.4	54	4.4
	Indian Sub-Continent	10	3.6	25	2.0
	Other	8	2.9	39	3.2
	Not known	46	16.6	260	21.1
Employment status	Unemployed	51	18.4	438	35.5
	Employed	143	51.6	478	38.7
	Childcare/houseperson	5	1.8	17	1.4
	Student/pupil	4	1.4	18	1.5
	Retired/invalidity/sickness	5	1.8	22	1.8
	Other	1	0.4	8	0.6
	Not known	68	24.5	253	20.5
Living arrangements	With others	143	51.6	553	44.8
	Alone	88	31.8	397	32.2
	No fixed abode	1	0.4	33	2.7
	Other	7	2.5	40	3.2
	Not known	38	13.7	211	17.1
Known drug-using history	Yes	115	41.5	656	53.2
	No	44	15.9	146	11.8
	Not known	118	42.6	432	35.0
Injecting status	Yes	9	3.2	83	6.7
	No	34	12.3	100	8.10
	Not known	234	84.5	1051	85.2
Age at death (years)	Mean	34.67		34.29	
	Minimum	16.19		15.59	
	Maximum	67.23		81.33	
	Std. Dev.	9.269		9.045	

Table 4: Principal underlying causes of death in UK SMR cocaine-related DRDs 2005-9

Cause of death	Sole		Any	
	Number	%	Number	%
Accidental poisoning	211	76.2	979	79.3
Intentional poisoning	7	2.5	27	2.2
Poisoning of undetermined intent	9	3.2	76	6.2
Other overdoses	1	0.4	2	0.2
Hanging	10	3.6	36	2.9
Asphyxiation/aspiration of gastric contents	0	0.0	2	0.2
Mental & behavioural disorders	21	7.6	51	4.1
Injuries	1	0.4	10	0.8
Drowning	0	0.0	2	0.2
Traffic accidents	0	0.0	5	0.4
Jumps/falls from height	0	0.0	1	0.1
Pneumonias & other lung conditions	1	0.4	2	0.2
Cardio-respiratory failure/arrest & cardio-vascular problems	10	3.6	21	1.7
GI/Hepatic/renal problems	0	0.0	2	0.2
Intestinal/alimentary obstruction	2	0.7	2	0.2
Epileptic seizures	2	0.7	2	0.2
Other effects on brain	1	0.4	4	0.3
Other	1	0.4	2	0.2
Unascertained	0	0.0	8	0.6
N	*277*	*100.0*	*1234*	*100.0*

Table 5: Principal substances implicated in UK SMR cocaine-related DRDs 2005-9

Substance	Number	%
Cocaine - any	1234	100.0
Cocaine - only	277	22.4
Alcohol	368	29.8
Heroin/morphine	594	48.1
Methadone	192	15.6
Other opiates/opioid analgesics	153	12.4
Drugs for anxiety/insomnia~~Hypnotics/sedatives~~ (mostly benzodiazepines)	220	17.8
Drugs for depression~~Anti-depressants~~	108	8.8
Drugs for psychosis~~Anti-psychotics~~	21	1.7
Anti-histamines	8	0.6
Anti-epileptics	3	0.2
Anti-Parkinson's	1	0.1
Amphetamines	56	4.5
Ecstasy/MDMA	62	5.0
GHB/GBL	14	1.1
Ketamine	14	1.1
Novel Psychoactive Substances (i.e. piperazines)*	13	1.1
Note: Piperazines were the only class of Novel Psychoactive Substances present in this period.		

Table 6: Common combinations of substances implicated in UK SMR cocaine-related DRDs 2005-9

Substance combination	Number	%
Alcohol & heroin/morphine	186	15.1
Alcohol & any opiate/opioid	229	18.6
Any opiate/opioid	718	58.2
Any medication (exc. opiates/opioids)	129	10.5
Any medication (exc. opiates/opioids) & alcohol	53	4.3
Any opiate/opioid & drugs for anxiety/insomnia~~hypnotics/sedatives~~	182	14.7
Any opiate/opioid & drugs for anxiety/insomnia~~hypnotics/sedatives~~ & alcohol	62	5.0
Any drugs for anxiety/insomnia~~hypnotics/sedatives~~ & alcohol	86	7.0
Any recreational drug (amphetamines, ecstasy, ketamine, GHB/GBL, NPS, etc.)	137	11.1
Any recreational drug (amphetamines, ecstasy, ketamine, GHB/GBL, NPS, etc.) & alcohol	44	3.6
Amphetamines and/or ecstasy	109	8.8
Amphetamines and/or ecstasy & alcohol	35	2.8

Notes: N = 1234. Totals for individual categories should not be added together.

Table 7: Presence of contributing factors associated with cocaine mono-intoxication acute poisoning in UK SMR cases, 2005-9

36 (13%) cases: pre-existing cardiovascular/cardiopulmonary conditions, which may lead to other complications and causes of death (e.g. ischaemic heart disease; coronary artery thrombosis; coronary thrombosis; thrombosis of left anterior descending coronary artery; coronary artery disease; coronary artery atheroma; myocardial fibrosis; hypertension; myocardial infarction; cardiomegaly; cardiomyopathy; left ventricular hypertrophy; left & right ventricular hypotrophy; myocardial hypertrophy; dissecting aortic aneurysm; necrosis)
23 (8%) cases: events possibly related to at-risk behaviours whilst on cocaine leading to external causes of death (e.g. immersion; head or multiple injuries i.e. road traffic accidents; hanging; cardio-respiratory arrest during restraint; intestinal obstruction in body-packers; toxicity in body-packers; mechanical obstruction of upper airway by foreign bodies => asphyxia)
8 (3%) cases: associated infections (e.g. bronchopneumonia; aspiration pneumonia; COPD; pneumonia; acute bronchitis; adult respiratory distress syndrome; myocarditis)
8 (3%) cases: pre-existing chronic medical conditions/natural disease (e.g. fatty liver change; alcohol liver disease; epilepsy/grand mal seizure; pulmonary hypertension & Cor Pulmonale)
In 62 (22%) cases, only cocaine and its well-known medical consequences were mentioned as the cause of death, including: myocardial infarction; cardio-respiratory failure/arrest, (acute) cardiac arrest/failure, sudden (cardiac) death; left ventricular failure; cardiac/ myocardial ischaemia/insufficiency; thromboembolism, thrombosis; myocardial damage, fibrosis; cardiac arrhythmia/disrhythmia; cerebral infarction, hypoxic brain damage/cerebral hypoxia, intracerebral haemorrhage; pulmonary oedema; pulmonary haemorrhage; aspiration of gastric contents/aspiration, asphyxia; pancreatitis; gastro-intestinal bleed/haemorrhage; renal failure.
154 (56%) cases: cocaine intoxication, overdose, poisoning, toxicity, fatal misuse, etc.
Notes: N = 277. More than one condition can be recorded in the medical cause of death; therefore totals for individual categories should not be added together. Cocaine was the only drug mentioned in the cause of death.