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Editors' choice

# Breaking worse: The emergence of krokodil and excessive injuries among people who inject drugs in Eurasia

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ABSTRACT

*Background:* Krokodil, a homemade injectable opioid, gained its moniker from the excessive harms associated with its use, such as ulcerations, amputations and discolored scale-like skin. While a relatively new phenomenon, krokodil use is prevalent in Russia and the Ukraine, with at least 100,000 and around 20,000 people respectively estimated to have injected the drug in 2011. In this paper we review the existing information on the production and use of krokodil, within the context of the region's recent social history.

*Methods:* We searched PubMed, Google Advanced Search, Google Scholar, YouTube and the media search engine www.Mool.com for peer reviewed or media reports, grey literature and video reports. Survey data from HIV prevention and treatment NGOs was consulted, as well as regional experts and NGO representatives.

*Findings:* Krokodil production emerged in an atypical homemade drug production and injecting risk environment that predates the fall of communism. Made from codeine, the active ingredient is reportedly desomorphine, but – given the rudimentary 'laboratory' conditions – the solution injected may include various opioid alkaloids as well as high concentrations of processing chemicals, responsible for the localized and systemic injuries reported here. Links between health care and law enforcement, stigma and maltreatment by medical providers are likely to thwart users seeking timely medical help.

*Conclusion:* A comprehensive response to the emergence of krokodil and associated harms should focus both on the substance itself and its rudimentary production methods, as well as on its micro and macro risk environments – that of the on-going syndemic of drug injecting, HIV, HCV, TB and STIs in the region and the recent upheaval in local and international heroin supply. The feasibility of harm reduction strategies for people who inject krokodil may depend more on political will than on the practical implementation of interventions. The legal status of opioid substitution treatment in Russia is a point in case.



## Introduction: the wheel of history

Russia, Ukraine and all other former Soviet countries share a long history of injection of home produced opioid and stimulant drugs that dates back to before the demise of the Soviet Union. Researchers have documented a lively and regionally varied pattern of small scale production and injection of home-made heroin (called *Cheornaya* in Russia and *Himiya* in Ukraine), methamphetamine (*Vint*) and methcathinone (*Jeff*) (e.g. Booth et al., 2008; Grund, 2002; Heimer, Booth, Irwin, & Merson, 2007; Platt et al., 2008). After the political changes of the 1990s, the home production of injectable drugs first spread rapidly across the Russian speaking region, but afterwards the pattern diversified. Since the late 1990s, imported Afghan heroin gradually replaced home produced drugs in many Russian cities and smaller communities, in particular those on and adjacent to heroin trafficking routes. The same was observed in the Baltic States (Zábranský et al., 2012) and in all five Central Asian countries (Renton, Gzirishvilli, Gotsadze, & Godinho, 2006; UNODCCP, 2000). But imported heroin never became widely available in Ukraine and the practice of home cooking remained common in both urban and rural areas, while the home production of amphetamines increased markedly (Booth et al., 2008; Shulga et al., 2010). In other places, the production of homemade injectables continued alongside emerging heroin markets.

In the last three to five years an increasing number of reports suggest that people who inject drugs (PWID) in Russia, Ukraine and other countries are no longer using poppies or raw opium as their

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starting material, but turning to over-the-counter medications that contain codeine (e.g. Solpadeine, Codterpin or Codelac). Codeine is reportedly converted into desomorphine (UNODC, 2012; Gahr et al., 2012a, 2012b, 2012c; Skowronek, Celiński, & Chowaniec, 2012). The drug is called *Russian Magic*, referring to its potential for short lasting opioid intoxication or, more common, to its street name, *krokodil*. Krokodil refers both to chlorocodide, a codeine derivate, and to the excessive harms reported, such as the scale-like and discolored (green, black) skin of its users, resulting from large area skin infections and ulcers. At this point, Russia and Ukraine seem to be the countries most affected by the use of krokodil, but Georgia (Piralishvili, Gamkrelidze, Nikolaishvili, & Chavchanidze, 2013) and Kazakhstan (Ibragimov & Latypov, 2012; Yusopov et al., 2012) have reported krokodil use and related injuries as well.

The objective of this paper is to review the existing information on the production and use of krokodil in the Eurasian region, the extent of its use and the associated harms. The paper examines the emergence and risk environment of krokodil within the context of the region's recent social history and the atypical homemade drug markets that (re-) emerged in the last decades of communism. Recent changes in local and international drug markets are considered in search of explanations for the emergence of this harmful drug. Possible harm reduction responses are explored and questions for further research presented.

## Methods

Our research strategy comprised: 1. Literature searches (search terms "krokodil," "crocodile", "desomorphine","desoxymorphine") of PubMed, Google Scholar, Google, and the media search engine Mool.com (krokodil, desomorphine) for grey, media and academic literature pertaining to krokodil use, production and effects; 2. Consultations with relevant researchers and NGO representatives in the region to ascertain a variety of perspectives and gain access to grey and unpublished literature; 3. A video search of the YouTube website. 39,400 hits on Google suggest that there is great interest in the issue of krokodil, but there is a dearth of published academic material on this topic, with the PubMed and Google Scholar searches yielding respectively 42 and 20 articles of which 4 and 7 were relevant. After deleting duplicates, 8 scientific journal articles were included in our analysis that specifically addressed the recent trend of krokodil injection. The Mool.com search yielded 3640 media reports, but most results were repetitive and contained little factual information. We therefore only drew on 7 recent publications from widely read websites. The consultations with regional experts pointed towards the same publications and further yielded a number of gray reports on the diffusion of krokodil in Russia and Ukraine. The YouTube search resulted in 30 videos of people with horrific mutilations reportedly resulting from injecting krokodil. Photographs of krokodil related injuries were additionally found at many news sites and blogs. Videos and photos were screened for injuries reported in Table 1. Many of the videos on YouTube and the pictures that circulate on the internet seem to be recorded in medical facilities, shot by, or with permission of the medical staff, when patients are being treated.

## Findings

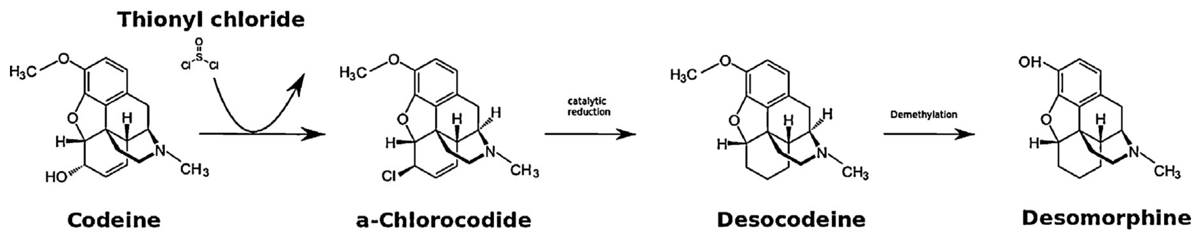
### *Krokodil production*

In considering the *drug* krokodil, two aspects are of importance, its pharmacology and its chemistry. The short half-life, limited high after the impact effect and, in particular the need for frequent administration may narrow the attention of users on the (circular) process of acquiring, preparing and administering the drug, leaving little time for matters other than avoiding withdrawal and chasing high, as reported in several popular magazines (e.g. Shuster, 2011; Walker, 2011). However, when the layers of bootleg chemistry and attribution are peeled off, what's left is an opioid analogue (or several ones) that, besides the variations in half-life, behaves pharmacologically not very different than heroin or *Hanka* (Haemmig, 2011). There are various paths to synthesize desomorphine from codeine, but the chemical process most commonly reported to be used by PWID in Russia and Ukraine is very similar to that of home-produced methamphetamine or *Vint* (Grund, Zábranský, Irwin, & Heimer, 2009; Zábranský, 2007) – a rudimentary version of a simple chemical reduction. The illicit production of krokodil reportedly involves the processing of codeine into the opiate analogue desomorphine (UNODC, 2012; Gahr et al., 2012a, 2012b, 2012c; Skowronek et al., 2012). Desomorphine (Dihydrodesoxymorphine-D or Permonid™) is an opiate analogue first synthesized by Small in 1932 (Small, Yuen, & Eilers, 1933). The analgesic effect of desomorphine is about ten times greater than that of morphine (and thus stronger than heroin), whereas its toxicity exceeds that of morphine by about three times (Weill & Weiss, 1951). The drug's onset is described as very rapid but its action is of short duration, which may lead to rapid physical dependence and frequent administration.

Homemade krokodil production generally involves small quantities of precursor drugs (e.g. 1–5 packs of codeine-based painkillers, or 80–400 mg codeine) and may take up to 45 min, although much shorter procedures (10–15 min) have been documented (International HIV/AIDS Alliance, ND). The process needs very little laboratory equipment and involves the use of highly toxic, low cost and easily available chemicals – strong alkalis (e.g. "*Mr. Muscle*" or "*Krot*"), iodine (standard medical solution), hydrochloric acid (industrial grade), red phosphorous (from matches), as well as organic solvents (gasoline, ethyl acetate or paint thinner). Codeine, generally combined with other pharmaceutical agents such as paracetamol, costs approximately 120 Rubles (€3) for a pack of 10 in Russia and is generally sourced from pharmacies. This produces a yield reportedly equivalent to 500 Rubles of heroin (John-Peter Kools, personal communication, 2012; Walker, 2011) making it an attractive heroin alternative to low income drug users.

The bootleg chemistry of krokodil can be broken down into two clearly distinguished steps: (i) the extraction of codeine from the medication; and (ii) the reconstruction of the codeine molecule into what is believed to be desomorphine. In the first step, codeine pills, syrup or a combination thereof are mixed with gasoline, Mr. Muscle or another strong alkali, often in a PET bottle. Subsequently this is vigorously mixed with acidified water and, after giving the mixture a rest, the aqueous part (containing the codeine) and the gasoline (supposedly containing all the other chemicals and ingredients) separate. After pouring the aqueous part into another container, some cooks then proceed to extract or "dry out" the codeine, where others may simply use the codeine solution produced. After its extraction, the codeine is mixed with iodine, hydrochloric acid and red phosphorous, in a glass container or in enamel cooking pots. The end of the reaction is determined by viewing and smelling the solution regularly.

It is important to note, however, that limited evidence exists pertaining to variations in production methods or what the ramifications of these methods are in terms of drug yield or contaminants in the resulting drug solution. While accounts by krokodil users on the importance of 'cooking skills', careful titration or filtering have been reported (International HIV/AIDS Alliance, ND), there is scant evidence of efficient solution neutralization at the end of the synthesis. Ethnographic observation of *Cheornaya* production in Russia found that weak bases such as cigarette ash or bicarbonate are commonly added after the reaction has completed (Abdala,




Source: RicHard-59, Wikimedia Commons.

**Fig. 1.** "Gold Standard" synthetic pathway from codeine to desomorphine.

Grund, Tolstov, Kozlov, & Heimer, 2006), but these are insufficient to raise the pH over 3 (Heimer, Kinzly, He, & Abdala, 2007).

A key question is whether krokodil cooks actually produce desomorphine; whether the synthetic paths followed can yield this particular compound. Savchuk, Barsegyan, Barsegyan, and Kolesov (2008) seem to suggest that simple reduction with iodine and phosphorus does yield desomorphine. Fig. 1 represents the "gold standard" synthetic pathway from codeine to desomorphine, that is, under standardized, optimal laboratory conditions. Desomorphine may be the opioid that the cooks intend to produce, but it is not what they necessarily end up with.

As shown in Fig. 1, the first step in the reaction is turning the codeine into α-chlorocodide, by reacting it with thionyl chloride. Subsequent catalytic reduction of α-chlorocodide yields dihydrodesoxycodeine and in the final step desomorphine is formed by demethylation (Eddy & Howes, 1935). Although opioid connoisseurs can be found to discuss the crucial importance of this first step – reacting the codeine with thionyl chloride (e.g. http://www.bluelight.ru/vb/threads/580958-Krokodil-Chemistry; http://www.bluelight.ru/vb/threads/611980-Desomorphine-(Krokodil)-experiences), these internet discussions may be beyond the reach or skills of the average krokodil cook in Russia or Ukraine. The name "krokodil" may be a clever neologism, a portmanteau of the discolored scale-like skin and α-chlorocodide (Priymak, 2011), but the use of thionyl chloride – which could be recovered from batteries – is, so far, conspicuously absent in the information reviewed for this paper.[1] This may suggest that the putative end product of the kitchen chemistry outlined above is often more likely to include other compounds than desomorphine, e.g. iodocodeine or morphine derivates. However, using gas chromatography, Savchuk et al. (2008) identified four synthetic analogues of desomorphine, (traces of) codeine and other compounds in "desomorphine" samples, with the desomorphine fraction ranging from traces to 75%. They suggest that in different regions of Russia "desomorphine is synthesized under different conditions and by different procedures" (Savchuk et al., 2008). Empirical research of krokodil's bootleg chemistry should clarify the actual synthetic pathways used and their relevance to public health and disease prevention and care.

Over-the-counter codeine formulae almost always contain other ingredients such as paracetamol, caffeine or terpinhydrate (an expectorant). Yet, it is not well known how any of these compounds influence the chemical reactions and their outcome, without carefully measuring the reactants or the processing time. Krokodil's actual psychoactive content may therefore strongly depend on the medicines, chemicals and reagents available locally, the actual reactions used and on the skills and preferences of those cooking and consuming the drug. Laboratory analysis of 'field' samples for drug content should provide more information on the actual (variations in) drug content of krokodil.

*Geographical diffusion and extent of krokodil use*

There is at present no reliable overview of the diffusion of krokodil in the region or of the scale of use. However, more than 50 cities have now reported krokodil use and/or related injuries. As of 2012 these comprise: Moscow and 27 other Russian cities (Andrey Rylkov Foundation, 2011); Kiev and 24 other Ukrainian cities (Natalia Dvinskykh, personal communication); as well as Aktobe city, Kazakhstan, and several Kazakh regions bordering with Russia (Ibragimov & Latypov, 2012; Yusopov et al., 2012). Among OST patients in Georgia, krokodil is now the most used opiate (Piralishvili et al., 2013). Krokodil production may have first emerged in Siberia and the Russian Far East some ten years back, but in the past three to five years has diffused into both urban centers and remote areas throughout Russia (Akhmedova, 2012; Shuster, 2011; Walker, 2011). According to Viktor Ivanov, the head of the Russian Federal Drug Control Service, the amount of krokodil seized in Russia increased 23 times between 2009 and 2011, while in some Oblasts it "has practically pushed out traditional opiates" (Shuster, 2011).

The estimated number of PWID in Russia was close to 2 million in 2008 (Mathers et al., 2008). 2.3% of the Russian population uses opioids annually and 1.4% heroin, compared to an annual prevalence of 0.4% opioid use in Western and Central Europe (UNODC, 2012). While actual epidemiological data is not available, a number of academic and media reports suggest that 5% or more of Russian drug users (approximately 100,000 PWID) may be injecting krokodil (Walker, 2011), while "various official estimates" place the numbers of Russian PWID using krokodil as high as one million (Shuster, 2011). Epidemiological data is critical to evaluating claims that the use of krokodil is reaching epidemic proportions in Russia (Walker, 2011), and potentially, the Ukraine. There are an estimated 290,000 to 375,000 PWID in Ukraine (Mathers et al., 2008). A recent national survey found that 7% of PWID have used krokodil in 2011 (Balakireva, 2012), suggesting that around 20,000 PWID in Ukraine may have used krokodil that year. Balakireva and colleagues furthermore found statistically significant differences in krokodil use between the cities in the study, with most krokodil use reported in Uzhhorod (35.6%), Simferopol (26.9%), Kyiv (21.7%), Chernivtsi (15.5%) and Donetsk (12.6%). Estimates from other countries are not available. Outside of the former Soviet region, krokodil has been reported in Germany (Der Spiegel, 2011) and in Tromsø in northern Norway (Lindblad, 2012).

*The risk environment of homemade drugs*

The home production of injectable drugs in the Russian speaking region is situated within a high risk environment. The concept of *risk environment* provides a trans-disciplinary scientific framework

[1] These include several discussions with NGO representatives, YouTube clips and two unpublished interviews with Ukrainian krokodil cooks.

for understanding drug use, addictive behaviours and the associated harms as a matter of '*contingent causation*' (Rhodes, 2002, 2009). According to Rhodes, drug use and HIV risk behaviours are determined by the interaction between individuals and their environments and subject to (physical, social, economic and policy) risk and protective factors that can be distinguished within the micro risk environment and the macro risk environment. The risk of HIV infection is, for example, affected by the type and frequency of risk behaviours practiced in groups of PWID and the structure of PWID networks, but these are contingent on government policies that may or may not support needle exchange programs or, conversely, repressive policing of drug users (Rhodes, 2009). Thus, drug use and risk behaviours do not exist in a vacuum, but are subject to a choice of dynamically interlocking factors. Importantly, human beings are not seen as merely helpless victims, for example of an enslaving substance, a psychological weakness or an unjust society, but rather as active actors in an environment where pharmacology, psyche and society meet and exercise mutual influence (Rhodes, 2009; Zinberg, 1984).

We suggest that the risk environment of production and use of krokodil and other homemade drugs is molded by several physical, social, economic and policy factors – both micro and macro – rooted in the last several decades of Communist rule in the region, when young people, inspired perhaps by the long tradition of *Samogon* (Moonshining) started cooking up injectable drugs emulating those available in illicit drug markets in *the West* (Grund et al., 2009; John, 1986; Zábranský, 2007). This home production developed in an era when closed borders effectively blocked the import of heroin and other '*Western*' drugs. Opium poppies were prevalent throughout the region, while opioid-based painkillers or ephedrine-based anti-cold drugs were available over-the-counter in the pharmacies. Hence, drug users in the Soviet Union turned to the poppy fields and pharmacies for their precursors, while many of the processing chemicals could (and can) simply be purchased in hardware stores or supermarkets. But in the USSR of the 1970s and 1980s there was even less tolerance for drug use, or deviance in general, than there was in the West, which was slowly coming to terms with the youth and protest movements that emerged in the 1960s. Drug users in the Soviet Union had a strong incentive to avoid the attention of the State's law enforcement agencies, and also that of *narcology*, the Soviet system of drug treatment re-established in the mid-1970s—a situation that overall changed little thereafter (Grund et al., 2009). In short, using drugs in the Soviet Union required skills, collaboration, trust and discretion.

Thus, the standard production units that emerged in the Eastern European republics of the USSR were small, tight-knit and clandestine groups of drug-injecting friends and close associates (varying from 3 to 8 PWID) among whom specialized roles and skills in the drug production process were divided. These small networks centered around the "cook," a bootleg chemist, while members shared or divided the responsibilities for discretely acquiring the raw materials (e.g. poppy heads or ephedrine), processing chemicals, 'laboratory' equipment (simple glassware or pots, various sizes of syringes and needles) and securing a protected environment for cooking the drugs with a gas or electric heater in kitchens, living rooms and basements (Dehne, Grund, Khodakevich, & Kobyshcha, 1999; Grund, 2002; Grund et al., 2009). The same network structure and roles were observed in Prague in the early 1980s, where the so-called *squads* engaged in the production of *Pervitin* (methamphetamine) (John, 1986; Zábranský, 2007), and among PWID in Poland producing *Kompot*, the Polish variant of *Cheorna*ya (Alcabes, Beniowski, & Grund, 1999).

While preparing the drug, the cook may be assisted by one or more crew members and syringes and other equipment frequently change hands. These syringes may also be used for injecting and shared routinely, particularly when scarce (Booth, Mikulich-Gilbertson, Brewster, Salomonsen-Sautel, & Semerik, 2004; Grund, 2002). Unlike the *Chrystal Meth* produced in the USA (Anglin, Burke, Perrochet, Stamper, & Dawud-Noursie, 2000), *Pervitin* in the Czech Republic (Zábranský, 2007) or *homebake* heroin in New Zealand (Bedford, Nolan, Onrust, & Siegers, 1987; Harris, 2013), the production of homemade drugs in the Russian speaking region does not result in a powdered or crystalline drug, but in a liquid drug. When ready for consumption, the liquid drug is shared by *frontloading* into syringes the group members use for injecting. Studies have shown that frontloading is widespread in this region (Dumchev et al., 2009; Grund & Merkinaite, 2009), a practice associated with HIV and HCV transmission.

In sum, these observations suggest that the relatively limited availability of black market opiates and stimulants and the relative ease of harvesting legal precursors to powerful analogues from the countryside and pharmacies inspired and sustained a Soviet-style *homemade* drug culture in the Eastern European region that remains radically different from those observed in countries where narco-traffickers dominate the production and distribution of drugs (Booth, Kennedy, Brewster, & Semerik, 2003; Grund et al., 2009; Grund, 2005; Subata & Tsukanov, 1999; Zábranský, 2007).

The physical and logistical exigencies of home production; its locus in networks of drug injecting friends and the high degree of cooperative action involved (in foraging for, producing and using the drugs); the multiple roles and ambiguous status of injecting paraphernalia; the routine occurrence of well-known risk behaviours (e.g. syringe sharing, frontloading) and those currently less well understood, such as the slapdash nature of the bootleg drug synthesis and its unpredictable outcomes in terms of actual drug product, purity and pollution— indeed all of these factors contribute to and interact within the vastly complex *high risk* environment of home drug production in the region.

*Krokodil injecting-related harms*

In recent years, harm reduction and drug treatment services from Russia, Ukraine, Georgia and Kazakhstan began reporting severe health consequences associated with krokodil injecting. Although serious localized and systemic harms have previously been associated with injecting homemade opiates and stimulants in the region (Grund, 2002; Volik, 2008), the harms associated with krokodil injecting are extreme and unprecedented. The most common complications of krokodil appear to be serious venous damage and skin and soft tissue infections, rapidly followed by necrosis and gangrene (Gahr et al., 2012a, 2012b, 2012c; Skowronek et al., 2012). Our research further identified an impressive, undoubtedly incomplete, list of injuries and symptoms (Table 1), reported in the media (e.g. Shuster, 2011; Walker, 2011) and identified in YouTube clips and photographs on the internet. Importantly, this list includes several parts of the body that are not typically used as sites for injecting drugs. This suggests that the ill effects of krokodil are not limited to localized injuries, but spread throughout the body (Shuster, 2011; UNODC, 2012), with neurological, endocrine and organ damage associated with chemicals and heavy metals common to krokodil production (Lisitsyn, 2010).

It is important to note that the described harms seem to become manifest relatively shortly after krokodil injecting is initiated. Present accounts of krokodil related harms often concern young people presenting in emergency rooms and surgeries with extreme and advanced complications. According to NGOs that work with people who inject krokodil, these young people have relatively short histories of using the drug. Mortality rates among young krokodil users are reportedly high (Akhmedova, 2012; Shuster, 2011; Walker, 2011), with official reports associating krokodil use with half of all drug-related deaths in at least two Oblasts (Walker, 2011).

**Table 1**
Reported harms from krokodil injecting.

| | |
|---|---|
| Localized damage | |
| • Thrombosis of the major vessels and arrosive bleedings;<br>• Large open ulcers, phlebitis and gangrene at and around injection sites;<br>• Skin and soft tissue infections to the bone;<br>• Limb amputations; | • Large eschars on the limbs and elsewhere on the body, pieces of dead skin that come off in one piece;<br>• Veins that ulcer and rot away from the inside, requiring surgical removal of the main veins in arms or legs, including the surrounding soft tissue and muscles. |
| Systemic damage | |
| • Pneumonia;<br>• Blood poisoning;<br>• Coronary artery burst;<br>• Meningitis;<br>• Rotting gums resulting in tooth loss;<br>• Bone infection, decayed structure of the jaw and other facial bones; | • Sores and ulcers on the forehead and skull;<br>• Gangrenous wounds on various part of the body;<br>• Rotting ears, noses and lips;<br>• Liver and kidney problems;<br>• Death. |
| (Symptoms of) Neurological damage | |
| • Speech impediments;<br>• Motor skills impairments; | • Affected memory and concentration;<br>• Personality changes. |

The risk environment of homemade drugs has traditionally been associated with both HIV and HCV infection in this region (Booth et al., 2008; Grund, 2002; Heimer, Booth, et al., 2007; Platt et al., 2008). Practices common to homemade drug production such as frontloading and 'indirect' sharing of injecting equipment are known to potentiate blood-borne virus transmission (Clatts et al., 1999; Grund, Kaplan, Adriaans, & Blanken, 1991) particularly in regard to HCV (Dumchev et al., 2009; Hagan et al., 2001), and are widespread. Laboratory replications demonstrate that the acidity of homemade drug solutions can render HIV inactive when stored in syringes (Abdala et al., 2006; Heimer, Kinzly, et al., 2007). But, given the much higher viral load in the blood of HCV infected people – generally 2 orders of magnitude greater for HCV than HIV – inactivation of HCV would require higher concentrations of acid or longer exposure times. Given the bootleg reduction described above, we expect that the krokodil solution may provide an *at-minimum* equally inhospitable environment for blood-borne viruses but exposure time may be crucial. Dumchev's findings suggest that frontloading may allow for sufficient contact time to inactivate HIV but perhaps not HCV (Dumchev et al., 2009).

Existing reports have emphasized the high potency of desomorphine and the need for frequent administration of krokodil, describing binge patterns that reportedly last over days (Walker, 2011). A need for frequent administration can increase exposure to unsafe injecting situations, in particular when with multiple drug injecting partners. During binges, impaired judgment and irrational behaviours resulting from exhaustion and sleep deprivation present further challenges to safer drug use. In particular, in unstable or transitioning drug markets, variations in potency could put (new) krokodil users at increased risk of overdose.

*Treatment and stigma: an exacerbation of harms?*

> "She won't go to the hospital, she just keeps injecting. Her flesh is falling off and she can hardly move anymore." – Sasha (in Walker, 2011)

Poor access to proper health care for PWID may exacerbate the described harms considerably. Medical help is reportedly often only available or sought after by people who inject krokodil at the late stage of disease in Russia and for many consumers the use of krokodil may end with severe mutilation, amputation and even death (Asaeva, Ocheret, & Fayziev, 2011; Walker, 2011). Why do krokodil users with phlebitis, gangrene or large eschars all over their body avoid seeking help, or do so only when their bodies seem beyond repair, when a long life disability or death seems to be the most likely outcome? Comprehensive answers to these questions or a more general discussion of access to health services of PWID and other most-at-risk populations (on which there is a rich literature) are beyond the scope of this paper and, indeed, our current understanding of krokodil and the context of its use. Yet, our review of the literature and popular media publications suggests a rather narrow focus on the pharmacological properties of the *drug* and the debilitating effects of its chemistry on the *set* of the user, with little consideration of the *setting* or *risk environment* in which krokodil injecting is situated (Rhodes, 2002, 2009; Zinberg, 1984).

Many scare stories have been published that emphasize the 'unprecedented' addiction potential of desomorphine and the debilitating effects of its bootleg chemistry on the brain and mental health of its users (e.g. Lisitsyn, 2010; Priymak, 2011; Vultaggio, 2012). Krokodil, "turns People into Zombies," living from one shot to the next one and having no consideration for other matters, such as their health, if we are to believe the popular media (e.g. Vultaggio, 2012). The chances of recovery are reportedly very grim or, more aptly, there may be no time for recovery. Many media outlets uncritically repeat what they are told by 'media experts,' fuelling misconceptions and moral panic: "*A heroin addict has a chance to become cured of his or her addiction – it is possible in 3 of 100 cases. Desomorphine kills all of its victims and it kills them very quickly. A heroin addict may live up to six or seven years. The life of a desomorphine addict is much shorter – two years maximum. Some may take it for five years, but many people die after taking their first dose of this drug*" (Priymak, 2011).

The image of krokodil users portrayed in the Russian language media – and the horrific footage accompanying it – contributes to what economist John Kenneth Galbraith dubbed "conventional wisdom," an idea widely accepted as true by both the public and 'experts,' but unexamined and preserving the status quo (Galbraith, 1958). Stigma among medical providers towards PWID in this region – and the resulting substandard treatment – is, as an anonymous expatriate medical worker recently pointed out, not only widespread and fuelled by lack of proper information, but also rooted in this type of conventional wisdom: "*They talk about these things with their family and friends, as we all do*" (Anonymous, personal communication, 2012). In countries where public campaigns or media position drug use as social evil and where health providers are viewed as closely aligned with law enforcement or other systems of social control (e.g. child protection agencies), PWID are likely to postpone seeking treatment for medical problems that need urgent professional care (Elovich & Drucker, 2008; Orekhovsky et al., 2002; Wolfe, Carrieri, & Shepard, 2010).

Elsewhere we have argued that the current response to drug use, HIV and infectious diseases in Russia and many former Soviet countries is strongly rooted in the Soviet Union's approach to deviance (Grund et al., 2009; Grund, 2002; Latypov, 2011). In Soviet times, narcology and psychiatry collaborated closely with law enforcement and security services in repressing political dissidents, drug users, prostitutes and sexual minorities alike, with leading psychiatrists and narcologists co-opted by the KGB as "trusted persons" (Latypov, 2012). Seeking drug treatment or getting arrested meant inclusion in a *narcological registry*, with personal and medical information shared among law enforcement, narcological centers and other agencies of state control. Registration as a *narkoman* entailed restrictions of civil rights and personal freedom, such as driving permits and professional licenses being revoked, targeted and unwarranted stop-and-frisk by the police looking for drugs or a bribe and the threat of compulsory treatment looming (Grund et al., 2009). In many former Soviet countries these practices have not significantly changed.

In Russia and many other post-Soviet countries, the old ideology lingers on in narcological institutes, out of sync with modern public and mental health concepts (Grund et al., 2009). Many narcologists continue to view addiction as criminal or moral deviance and not as a disease. Narcological dispensaries continue to share information with law enforcement (Mendelevich, 2011). The threat of removal of child custody rights may impede women's access to health care in particular (Shields, 2009). Stigma and discrimination, hostile treatment and lack of confidentiality are persistent in the treatment of PWID and must be viewed as important barriers to timely seeking medical care (Beardsley & Latypov, 2012; Mendelevich, 2011; Wolfe et al., 2010). PWID have therefore strong incentives to avoid narcological facilities and, by association, other state health services. In their personal "hierarchy of risk," seeking help for significant health problems is subordinated by the need to stay under the radar of the authorities (Connors, 1992). Several of the YouTube clips on the internet furthermore document not only the gravity of harms among krokodil users, but also poor and inhumane treatment of those hospitalized with krokodil related injuries. In one video a man's leg is sawn off under the knee with a lint saw in what seems not to be a surgical unit, but perhaps a common hospital ward. The man sits wide-awake in an ordinary wheelchair and holds his leg himself above a bucket, which was lined with a garbage bag just before. These videos and case reports (Asaeva et al., 2011; Daria Ocheret, personal communication, 2012; Sarah Evans, personal communication, 2012) suggest that the care provided to those with krokodil related injuries may be (grossly) substandard, sometimes exacerbated by improper diagnosis and faulty clinical decisions.

*Absence of opioid substitution treatment*

An important practical concern is the absence of opioid substitution treatment (OST) in surgical units and general hospitals. Except for Russia (where OST is banned through existing legislation), Turkmenistan (where national authorities are still 'considering' whether to introduce OST or not) and Uzbekistan (where OST was discontinued in 2009), all countries in Eurasia have introduced opioid substitution treatment (OST), predominantly in state health facilities. However, OST coverage remains well below under 5% of estimated PWID in the majority of the former Soviet countries. In most of these countries the highly centralized and vertical health care structures inherited from the Soviet era impede the provision of integrated, patient-centred health care, in particular for PWID and other vulnerable populations, where an integrated approach is deemed of crucial importance to containing the clustering epidemics of HIV, hepatitis and tuberculosis. As a rule, OST programs are almost exclusively run by narcological centers, while integration with e.g. HIV, TB or hepatitis treatment or primary care remains rare and take-home OST doses are authorized only in the three Baltic states and Kyrgyzstan (Latypov, Bidordinova, & Khachatrian, 2012). These restrictions pre-empt the use of substitution medication as an adjunct treatment to facilitate access and adherence to in-patient treatment in, for example, surgeries and general hospitals. The prospects of acute withdrawal when hospitalized offer PWID further incentives for avoiding biomedical treatment.

## Discussion

A number of factors appear to have precipitated and exacerbated the use of krokodil in Russia and the Ukraine. These include changes to heroin availability, purity and price due to heroin 'droughts' and increased police interdiction; legislative changes targeting poppy straw and rising poverty levels in Russia since the start of the 2008 global economic crisis (Rapoza, 2012). In 2010 the total opium production in Afghanistan (the source of most of the heroin used in the Eurasian region) was 48% lower than in the previous year (UNODC, 2010). Almost half of the 2010 crop was reportedly destroyed by an unknown, perhaps fungal, disease that spread in the major opium production areas in Helmand, Kandahar and Oruzgan provinces (UNODC, 2010; Oppel, 2010; UNODC, 2012). These shortages have resulted in opioid users increasingly turning to injecting krokodil, acetylated opium and, in some parts of the country, fentanyl (UNODC, 2012) or other pharmaceuticals, such as Tianeptine ("Coaxil" a modified tricyclic antidepressant,) or Tropicamide (eye drops with anticholinergic effects, which when injected can induce delirious states) (Wimhurst, 2011; Yusopov et al., 2012). In Ukraine, legislative changes in 2010 severely increased the punishment for possession of acetylated opium (Skala & Maistat, 2012). This, accompanied by stricter enforcement, resulted in the decreasing availability of poppy straw and the emergence of krokodil use (Natalia Dvinskykh, personal communication, 2012). Home produced and pharmacy drugs are significantly cheaper than heroin or other imported drugs and therefore popular among the poorer segments of drug using populations (Andrey Rylkov Foundation, 2011; Balakireva et al., 2006; Priymak, 2011; Shuster, 2011; Walker, 2011).

*Krokodil and harm reduction*

A thorough assessment of the extent and nature of the krokodil, or its aetiology, has not yet been conducted. The injuries associated with krokodil injecting are excessive and may signify a *health emergency in the making*, in particular if this phenomenon were to diffuse more widely among PWID in the region. Since krokodil is inexpensive and easily made, with decreasing availability of heroin or poppies in local drug markets, more young people may be at risk of using this drug, potentially resulting in higher numbers of people vulnerable to the drug's grave physical and mental injuries, but also to HIV and HCV transmission and other injecting related harms.

The harms attributed to krokodil injecting are not only a product of the substance itself but of the micro and macro risk environments in which krokodil injecting is situated. Effective harm reduction interventions therefore need to focus beyond individual and practice level changes, on the wider environment which either enables or restricts the adoption of safe drug production and injecting practices (Rhodes, 2009). The most obvious and pragmatic structural harm reduction intervention to impact on the prevalence and therefore harms associated with the injection of krokodil and other opioids – whether homemade or imported – is the repeal of OST prohibition in Russia and expansion of substitution treatment access in the Ukraine, Georgia, Kazakhstan and throughout the region. Provision of OST in general hospitals as an 'adjunct treatment' has the potential to increase hospital access for PWID as fear of enforced withdrawal is one barrier to timely presentation for krokodil related infections. Widespread discriminatory treatment of PWID in narcology and hospital units, with the threat of communication links between biomedicine and law enforcement, are also significant barriers to effective medical care access (Wolfe et al., 2010). Amelioration of these systemic barriers ultimately requires an institutional reframing of illicit drug use and dependency from a moral and criminal concern to a social structural and health issue. The engrained social political reticence to implementing evidence based effective harm reduction, observed in Russia and several other former Soviet countries, does not make this an easy task. However, potential lessons can be gained from other countries regarding innovations in grass roots, clinic and outreach based care.

In the United States context, where discrimination and neglect of PWID in mainstream hospital systems is also documented (Bourgois & Schonberg, 2009), marginalised PWID typically present for injecting-related medical care at a late stage, with cellulitis and soft tissue infections representing one of the highest non-psychiatric reasons for emergency department hospital admissions (Harris, Young, & Organ, 2002). By providing coordinated surgical intervention for people with soft tissue infections, substance use counselling and social services, specialized out-patient clinics and outreach programs have been successful in reaching homeless and marginalized PWID (Harris et al., 2002). A wound and abscess care clinic in a syringe exchange program reportedly increased patient–clinician interactions and provided opportunities for referrals to services such as HIV counselling and testing, medical care, and drug treatment at an estimated cost of 5 USD per patient (Grau, Arevalo, Catchpool, & Heimer, 2002).

Late presentation, as for those with krokodil related infections, precipitates more severe outcomes, including potential amputations, skin grafts and other major surgery. Providing easily accessible, non-judgmental and quality care for people with soft tissue infections can have a significant and cost saving impact on hospital admissions and importantly, can encourage the timely presentation for care among marginalized PWID (Grau et al., 2002; Harris et al., 2002). Other successful initiatives in the US context include van-based mobile health clinics for the homeless and other street-based populations (Altice, Springer, Buitrago, Hunt, & Friedland, 2003; Pollack, Khoshnood, Blankenship, & Altice, 2002; Wlodarczyk & Wheeler, 2006), a mobile methadone clinic for the homeless (Bourgois & Schonberg, 2009), and a variety of (peer-based) outreach education and needle and syringe distribution initiatives (Broadhead et al., 1998; Des Jarlais, McKnight, Goldblatt, & Purchase, 2009; Needle et al., 2005). Again, while some of these interventions are not immediately feasible in the repressive post-Soviet policy contexts, work can begin with local drug user organizations and progressive medical professionals to explore options for engaging users of homemade injectables with timely medical care.

Clearly not all users of homemade injectable drugs experience the extreme harms associated with krokodil. Although circulatory damage and soft tissue infections among injectors of *Cheornaya* or *Vint* are not uncommon, the current widespread reports of advanced stadia of necrosis and gangrene are unprecedented. Importantly, drug users in New Zealand also produce injectable heroin substitutes from codeine and morphine based medications (known as "Homebake") (Bedford et al., 1987). Similarly, before heroin became more widely available in the 1990s, so did users in the Czech Republic, where the product was called "Braun" (Zábranský, 2007). Neither of these practices has however been associated with the extreme harms reported among krokodil users in Russia and Ukraine. Indeed, the accompanying commentary on the homebake scene in New Zealand (Harris, 2013) suggests that harm reduction strategies may well be possible in addressing this emergency situation. These include the introduction, at a peer-based grass roots level, of alternative homemade injectable recipes, which involve the same precursor – over-the-counter codeine based tablets – but in utilizing different processes and chemicals produce a safer opioid injectable (Harris, this issue). While these suggestions may be contentious, in a context of restricted opioid substitution treatment access, repressive treatment approaches and even more repressive drug enforcement, working with drug user organizations to introduce safer and equally cost effective injectable recipes may be the most immediately effective and pragmatic way of reducing harm. Providing simple Litmus paper might be a good start and tool for outreach.

*Recommendations for further research*

A trans-disciplinary research effort is required to understand comprehensively all aspects of this recent and disturbing drug trend. There is a pressing need to map the actual field chemistry of krokodil, in all its manifestations. Krokodil's active ingredient is presumed to be desomorphine (Gahr et al., 2012a, 2012b, 2012c; Skowronek et al., 2012; UNODC, 2012), but the actual solution injected may hold various opioid alkaloids, that could be derived from codeine, depending on the reactants available, reaction times and temperatures, and ultimately the chemistry skills of the krokodil chef. An understanding of the chemical composition of substances that go by the name "krokodil" can both inform tailored treatment interventions and provide the basis for developing harm reduction advice for potentially safer recipes and manufacturing processes.

The reported effects of krokodil on the brain and mental health of its users are concerning. Given the inferior chemistry involved in making the drug, the 'brain damage' and mental health problems ascribed to krokodil may well be more than just the latest drug panic. Nevertheless, the actual chemistry of krokodil and its effects on the body and brain – for example, what parts are affected and are effects permanent – remain at this point virtually unexplored. Laboratory analysis of krokodil samples for contaminants and careful neurological evaluations of hospitalized krokodil users are needed to increase our understanding of the effects on the human body and mind and contribute to effective treatment and pragmatic harm reduction approaches. Precise data on krokodil related morbidity and mortality are also scarce. How many krokodil users actually experience (severe) physical or mental health harms, how these are distributed within the population or their direct causative mechanism remain as of yet unclear and are in dire need of scientific scrutiny. Emergency room or surgery data analysis could indicate the number of people who inject krokodil seeking treatment and for what conditions. Likewise, coroner's office data or 'sociological' autopsies could help to gain insight in both the extent and the specific nature of krokodil related deaths.

Qualitative research is well placed to investigate the feasibility and acceptability of alternative injectable opioid recipes for current krokodil users and is vital in informing effective evidence-based harm reduction responses. Qualitative studies are additionally required to explore perceptions of krokodil use among PWID, including experiences of initiation, patterns of use and experienced barriers and facilitators to accessing timely medical care. Ethnographic observation is crucial to improving our understanding of the self-preparation of krokodil and the contexts in which production occurs. Epidemiological studies are needed to map the extent of krokodil use and production in the Eurasian region and, where possible, its aetiology. Laboratory research is also required to investigate the chemical properties of krokodil and explore alternative manufacturing processes and ingredients that could result in an acceptable safer injectable. The hidden nature of krokodil production and use will require engaging with PWID on issues around the safer use and production of homemade drugs. Rapid community-based and participatory research (Hayashi, Kerr, Suwannawong &

Kaplan, 2011; Hayashi et al., 2012), would allow for effectively translating research findings back into practical harm reduction interventions at the community level and for peer-based diffusion of harm reduction information into the region's PWID networks.

Research is also required to capture changes and transitions in krokodil use, including – potentially – in its chemical composition. Some of these changes may be precipitated by recent legislation in Russia, which – on June 1, 2012 – banned over-the-counter sale of medicines containing codeine, and Kazakhstan, where an interministerial decree was issued in October 2011 to address the increasing misuse of Tropicamide and over-the-counter medications that contain codeine and where since 2011 codeine containing medications, such as Solpadeine, Unispaz, Antispasm and Pentalgin-P are sold by prescription only (Yusopov et al., 2012). While no data are available on subsequent changes in either codeine availability or drug use patterns in Russia and Kazakhstan, experience from neighbouring countries suggests that prohibitive measures alone will not solve the problem. In the Ukraine previous bans of over-the-counter sales of (pseudo)ephedrine, the key ingredient for producing methamphetamine or methcathinone, resulted in shifts in the use of precursors and the rise of *Boltushka* injecting, cathinone cooked from medications that contain phenylpropanolamine (Chintalova-Dallas, Case, Kitsenko, & Lazzarini, 2009), a practice associated with Manganese-induced Parkinsonism (de Bie, Gladstone, Strafella, Ko, & Lang, 2007). Research is also required to address the differences in harms associated with krokodil and *Vint*, despite similarities in production process. The more severe harms associated with krokodil use might be due to the shorter half-life of the opioid (versus the longer acting methamphetamine), leading to more frequent injections with caustic solutions. It may also reflect the superior chemistry skills of *Vint* cooks that rely on decades-long experience within the *Vint* subculture (John, 1986; Shiryanov, 2001), as compared to the half a decade of recent experience with krokodil. One way or another, the synthesis of desomorphine from codeine seems hard to accomplish under the primitive 'laboratory' conditions sketched above – other reactants and equipment seem required to reach a proper drug yield and non-toxic solution. Changes and transitions in krokodil use, as previously noted, are also affected by shocks to heroin production and supply, such as caused by the 2010 heroin 'drought'. While the Afghan opium production resurged to 5800 tons in 2011, UN officials have noted that another disease observed in the poppy fields in 2012 may lead to further heroin shortages in the near future, potentially fuelling the use of krokodil (Angela Me, personal communication, 2012). Such market transitions should not only be monitored but, in order to allow for effective and timely harm reduction interventions, the information generated should be fed back into harm reduction and public health networks on the shortest notice possible.

## Conclusion

As detailed, krokodil use is situated within a multifaceted high risk environment. This environment is comprised of a multitude of macro and micro risk factors, such as the poor chemical synthesis of the drug itself and the resulting contaminants in the drug solution injected; the home-based production environment; drug manufacture and distribution practices; the frequency of production and injection; the poverty, social marginalization and stigma experienced by many PWID; rising heroin prices; unavailability of OST; stigmatizing drug treatment approaches and fear of law enforcement and child removal. Many questions pertaining to the production and use of krokodil – its pharmacology and chemistry – persist. Our analysis strongly suggests that, in order to gain a comprehensive understanding of the emergence of krokodil and the associated harms, we must on the one hand focus on the substance itself and (variations in) its rudimentary production methods and go beyond these on the other hand in exploring the micro and macro risk environments in which the drug emerged – that of the ongoing syndemic of drug injecting, HIV, HCV, TB and STIs in this region (Singer, 2009). We suggest that *biochemical—social cultural—political historical—public policy* interactions have resulted in the emergence of krokodil. These interactions exacerbate negative health outcomes in communities affected by krokodil, as well as deleterious social outcomes. Whether reduction of krokodil related harm is possible may depend more on macro environmental or political factors than on the practical feasibility of potential interventions, such as those discussed above. However, the current drug policy climate in the region presents a disabling, not an enabling environment for the required health interventions (Beardsley & Latypov, 2012; Jolley et al., 2012).

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