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Nationwide increase in hospitalizations for heroin-related soft tissue infections: Associations with structural market conditions

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ABSTRACT

Introduction: Little is known about trends in national rates of injection-related skin and soft tissue infections (SSTI) and their relationship to the structural risk environment for heroin users. Use of Mexican-sourced "Black Tar" heroin, predominant in western US states, may have greater risk for SSTI compared with eastern US powder heroin (Colombian-sourced) due to its association with non-intravenous injection or from possible contamination.
Methods: Using nationally representative hospital admissions data from the Nationwide Inpatient Sample and heroin price and purity data from the Drug Enforcement Administration, we looked at rates of hospital admissions for opiate-related SSTI (O-SSTI) between 1993 and 2010. Regression analyses examined associations between O-SSTI and heroin source, form and price.
Results: Hospitalization rates of O-SSTI doubled from 4 to 9 per 100,000 nationally between 1993 and 2010; the increase concentrated among individuals aged 20–40. Heroin market features were strongly associated with changes in the rate of SSTI. Each $100 increase in yearly heroin price-per–gram-pure was associated with a 3% decrease in the rate of heroin-related SSTI admissions. Mexican-sourced-heroin-dominant cities had twice the rate of O-SSTI compared to Colombian-sourced-heroin-dominant cities.
Discussion: Heroin-related SSTI are increasing and structural factors, including heroin price and source-form, are associated with higher rates of SSTI hospital admissions. Clinical and harm reduction efforts should educate heroin users on local risk factors, e.g., heroin type, promote vein health strategies and provide culturally sensitive treatment services for persons suffering with SSTI.

1. Introduction

Bacterial skin and soft tissue infections (SSTI), specifically cellulitis and skin or soft tissue abscesses, are the most common reason for hospitalization of persons who inject drugs (PWID; Ciccarone et al., 2001; Ebright and Pieper, 2002) and carry high social burden and health care costs (Binswanger et al., 2000; Binswanger et al., 2008; Takahashi et al., 2007, 2010). Prevalence estimates of SSTI among PWID range widely: from 10% of PWID at a supervised injection program in Vancouver (Lloyd-Smith et al., 2008), 20% of PWID in Tijuana (Pollini et al., 2010), 24% of heroin PWID inpatients in Detroit (Crane et al., 1986), 32% of street sampled heroin PWID in San Francisco (Binswanger et al., 2000) to 34% of heroin injectors in Glasgow (Ramsay et al., 2010). Takahashi et al. (2010) estimate that 0.07% of all US non-Federal hospitalizations in the United States were due to SSTI among heroin users generating costs over $193 million in 2001 alone. In San Francisco, 7% of all hospital admissions at the large county hospital were for SSTI costing on average $9.9 million per fiscal year; of these cases 70% were in heroin injectors (Ciccarone et al., 2001). The individual burden of heroin-related SSTI in San Francisco has been described as a "hidden epidemic of suffering" (Ciccarone et al., 2000). SSTI have a negative impact on quality of life with persistent pain, mobility restrictions and stigmatization due to disfigurement and wound odor (Palfreyman et al., 2007; Pieper et al., 2007). Stigmatization in turn leads to non-adherence to medical care and self-care prac-

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tices such as self-lancing abscesses (Bourgois and Schonberg, 2009; Ciccarone et al., 2000; Fink et al., 2013; Messac et al., 2013).

What little is known about the risk factors for SSTI among heroin PWID is focused on individual behaviors. Behavioral risks include type of drug injected (heroin and cocaine, i.e., speedball; Murphy et al., 2001; Spijkerman et al., 1996), route of injection (subcutaneous or intramuscular vs intravenous; Binswanger et al., 2000; Murphy et al., 2001) frequency of subcutaneous injection; (Binswanger et al., 2000; Hope et al., 2016; Spijkerman et al., 1996) and reuse of syringes (Murphy et al., 2001). HIV infection was an independent risk in one study (Spijkerman et al., 1996) but not another (Murphy et al., 2001). Similarly skin cleaning prior to injection was seen as protective in a case-control study (Murphy et al., 2001) but not so in a cross-sectional one (Binswanger et al., 2000). Type of drug injected is crucial with injection of heroin and speedball (heroin and cocaine) increasing (Lloyd-Smith et al., 2008; Murphy et al., 2001) and injection of methamphetamine decreasing risk for SSTI (Phillips and Stein, 2010).

Moving beyond individual behavioral risks we consider the structural risk environment – a framework that conceptualizes individual behavior within wider social, environmental and political contexts in which harms result from interactions between macro- and micro-level forces (Rhodes, 2009). For heroin injectors the structural risk environment includes drug supply, i.e., heroin source, form and distribution, which moderates the relationship between individual risk behaviors and health. Risks emanate from global supply, e.g., poppy cultivation, trafficking and interdiction, down to local settings e.g., drug market conditions, (Curtis et al., 1995) syringe availability (Bluthenthal et al., 2000) and size (Bobashev and Zule, 2010) and social norms (Sherman et al., 2002), all shaping micro-level drug use behavior, e.g., injection route, frequency and hygiene (Ciccarone, 2009; Ciccarone and Bourgois, 2003).

Heroin source and form may entail some structural risk for SSTI. The robust geographic division of US heroin markets by source-form has existed, for political and economic reasons, for the past two to three decades (Ciccarone, 2009; Ciccarone et al., 2009). Since 1985, "Black Tar" heroin (BTH) has been the predominant form of heroin available in the Western U.S. (US Drug Enforcement Administration, 2000). Mexican in origin, BTH derives its name from its dark brown to black color, as well as its semi-solid, tarry consistency. PWID in Tijuana, Mexico, the majority of whom used BTH, reported a lifetime prevalence of SSTI of 46% (Pollini et al., 2010). Reports suggest BTH use is associated with several clinical SSTI including abscess and cellulitis (Ciccarone et al., 2001), necrotizing fasciitis (Dunbar and Harruff, 2007) and specifically various Clostridia infections including tetanus (Bardenheier et al., 1998), wound botulism (Center for Disease Control and Prevention, 1995; Passaro et al., 1998) and myonecrosis (Bangsberg et al., 2002).

Heroin market conditions, e.g., retail price and purity, are also components of the structural risk environment. Our analyses of structural changes in the US heroin supply, 1990–2008, revealed that the entry of a novel source-form of powder heroin (PH) from Colombia led to a nationwide decline in the price and increase in the purity of heroin (Rosenblum et al., 2014). Cities in the mid-US with more heroin source-forms had more competition and the greatest decline in purity-adjusted price over the time period (Rosenblum et al., 2014). Another study used representative national hospital data combined with heroin market data to investigate a link between structural heroin market characteristics and heroin-related overdose over 17 years. We found that each $100 decrease in the price per gram pure of heroin resulted in a 3% increase in the number of HOD hospitalizations (Unick et al., 2014). An unexpected finding was that Colombian-sourced heroin had a positive effect, independent of purity, on the rates of HOD in our national model (Unick et al., 2014).

This study focuses on identifying national trends in heroin-related SSTI and quantifying the role that the heroin market, specifically price, purity, and heroin source-form (i.e., BTH vs PH), has on community SSTI risk. This is the first study, to our knowledge, that uses representative national hospital data combined with US Drug Enforcement Administration (DEA) heroin market data to investigate a link between structural heroin market factors and SSTI. We hypothesize that decreases in heroin price are associated with higher hospitalization rates nationally for SSTI and that communities with predominantly BTH have higher rates of SSTI hospitalizations.

2. Methods

2.1. Sample metropolitan statistical areas

We used Metropolitan Statistical Areas (MSAs), to define geographic entities as defined by the Office of Management and Budget. These units function as integrated economic and social entities that span multiple counties but have a common urban core population over 50,000 (Office of Management and Budget, 2010). We used 27 MSAs to construct the price and purity series for retail level heroin purchases and samples (under 1 g) between 1993 and 2010 in the DEA System to Retrieve Information from Drug Evidence (STRIDE) dataset. These 27 MSAs were selected because they had data reported in STRIDE for each of the years analyzed. They also represent all of the top 15 and 22 of the top 30 MSAs by population size in the country. Table 1 lists all 27 MSAs with heroin price and purity data. Albuquerque, Atlanta, Dallas, Detroit, El Paso, Houston New Orleans and San Antonio were excluded from the regression analysis due to restrictions on identifying hospital locations, which prevent specification of the hospitals' MSA (Agency for Healthcare Research and Quality Healthcare Cost and Utilization Project (HCUP), 2008). The 19 MSAs with heroin overdose frequency counts identify the MSAs included in the regression analysis.

2.2. Counts of opiate-related skin and soft tissue injury hospital admissions

The dependent variable for these analyses is a count of opiate-related skin and soft tissue injury (O-SSTI) hospital admissions in a given hospital in a given year in one of 19 MSAs. O-SSTI hospitalization data come from the Nationwide Inpatient Sample (NIS), an approximately 20-percent stratified national random sample of United States Community Hospitals (HCUP, 2008). For each year's sample of hospitals, the NIS randomly draws 20% of hospitals from its stratified sampling frame to construct the dataset so each individual hospital only appears a limited number of times (a mean of 3.7 times per hospital). Overall there were 3409 hospitals sampled from the 19 MSAs. Data from 1993 through 2010 NIS were used to estimate the number of O-SSTI in hospitals in each of 19 MSAs.

Cases of O-SSTI were identified using ICD-9 codes included in the NIS discharge records. Individuals were considered to have a SSTI if they had ICD-9 codes 681.1–682.9, were between the ages of 15 and 65 and did not have a diagnosis of diabetes type 1 or type 2. We also tested a model that included the above SSTI ICD-9 codes and codes for gas gangrene, wound botulism and necrotizing fasciitis. These second diagnoses were very rare, were highly correlated ($r = 0.99$), did not improve the fit of models presented here and did not change any of the inferences. We elected to go with the more parsimonious model. We also considered a number of drug comorbidities, from less sensitive all drug models that included all the dependence, abuse, intoxication and poisoning ICD-9 codes for amphetamines, cocaine, heroin, opiates and general drug categories. All the drug