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Prevalence and correlates of '*agua celeste*' use among female sex workers who inject drugs in Ciudad Juarez, Mexico

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ABSTRACT

Background: Agua celeste, or "heavenly water", is the street name for a sky-blue colored solvent reportedly inhaled or ingested to produce an intoxicating effect. Study aims were to (1) describe prevalence of *agua celestse* (*AC*) use, and (2) identify correlates of lifetime and recent use of *AC* use among female sex workers who also inject drugs (FSW-IDUs) in northern Mexico.
Methods: Between 2008 and 2010, baseline data from FSW-IDUs ≥ 18 years old living in Tijuana or Ciudad Juarez participating in a longitudinal behavioral intervention were analyzed using logistic regression.
Results: Among 623 FSW-IDUs (307 from Tijuana and 316 from Ciudad Juarez (CJ)), 166 (26%) reported ever using *AC*, all of whom lived in CJ. Among the CJ sample, lifetime prevalence of *AC* use was 53%, median age of first use was 16 years (IQR: 14–23), and 10% reported it as their first abused substance. Ever using *AC* was independently associated with ever being physically abused and younger age, and was marginally associated with initiating injection drug use and regular sex work at age eighteen or younger. Among those ever using *AC*, 70/166 (42.2%) reported using it within the last 6 months, which was independently associated with using drugs with clients before or during sex, being on the street more than 8 h per day, and younger age.
Discussion: We observed considerable geographic variation in the use of *AC* in northern Mexico. Future studies exploring factors influencing use, its precise formulation(s), and its potential health effects are needed to guide prevention and treatment.

1. Introduction

The relative inexpensiveness, ease of availability, and rapidly achieved intoxicating effects of inhalants make them particularly attractive to adolescents. There are four main types of inhalants: volatile solvents, gases, aerosols and nitrites. Inhalants may alter moods and create a euphoric state that can be accompanied by lightheadedness and hallucinations (Feron et al., 1998). Nitrites, sometimes known as "poppers", may enhance sexual pleasure. Sometimes referred to as "sniffing", "huffing", or "bagging", the primary objective of inhaling volatile substances is to deliver the highest concentration of the substance to the lungs and subsequently the brain (Espeland, 2000). "Sniffing" typically means the solvent is inhaled from an open container, whereas "huffing" refers to covering the nose and mouth with a solvent-soaked cloth while inhaling. "Bagging" involves placing a solvent soaked bag over one's mouth while inhaling. "Huffing" and "bagging" are especially harmful because solvents are often ingested during the inhalation process (Brouette and Anton, 2001). Independent of the mode of delivery, the intoxication typically lasts only a few moments, requiring inhalant users to engage in repeated use in order to prolong the effects. Serious health effects may occur with successive inhalations, including loss of consciousness, seizures, nervous system damage, and even death (Flanagan and Ives, 1994; Kurtzman et al., 2001). Cognitive damage is a particularly serious health effect, especially common in individuals who huff the solvents (Lubman et al., 2008).

According to data from Mexico's 1998 National Survey on Addictions, inhalants were the third most prevalent drug used in Mexico after marijuana and cocaine (Secretaria de Salud, 1998).

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In 1998, household surveys conducted in urban areas throughout Mexico among populations 12–65 years of age provided a cumulative prevalence of lifetime inhalant use of 0.80%, with prevalence at 1.07% in Tijuana and 0.30% in Ciudad Juarez, suggesting some degree of regional variation (Medina-Mora and Ortiz, 1988; Secretaria de Salud, 1998). By 2005, the prevalence of inhalant use had increased to 2.83% in Tijuana and to 0.78% in Ciudad Juarez (Rojas Guiot et al., 2009).

Due to their accessibility, the most commonly abused inhalants in Mexico include paint thinner, glues, and aerosol sprays (Medina-Mora et al., 2003; Secretaria de Salud, 2008). A national high school survey conducted in 1998 in Mexico City found that among female adolescents, inhalants were the most common drug used after marijuana (Medina-Mora et al., 2003). The most recent school surveys in Mexico show inhalants are the most common substance of abuse among male and female students between 7th and 9th grade (Villatoro et al., 2009). Inhalant use is more common within this age group than marijuana use, with 7.4% of males and 6.7% of females reporting inhalant use compared to 5.6% and 2.7% respectively for marijuana (Villatoro et al., 2009).

In the context of an ongoing study of female sex workers who inject drugs (FSW-IDUs) in Tijuana and Ciudad Juarez, our study team became aware that some participants were using an inhalant referred to as *agua celeste*, or "heavenly water". A literature search revealed that *agua celeste* was reported as part of the Mexican pharmacoepia as early as 1885, when it was described as a mixture of copper sulfate and ammonia which creates a sky-blue color (Hagenibuch, 1885). Within Mexico's illicit drug market, early anecdotal reports suggest that *agua celeste* has mainly been used among children and adolescents along the Mexico–U.S. border (Chacon, 2007), in a similar way that toluene was introduced four decades ago (Medina-Mora et al., 1997).

Although reports of *agua celeste* are lacking in the peer-reviewed literature, one account of *agua celeste* use within the Mexico-US border region dates back more than a decade (Ramos, 1998). A mixed-method study among not-in-treatment drug users in San Antonio and El Paso, Texas reported *agua celeste* as a mixture of tannery processing products including benzene, formaldehyde, and methyl ethyl ketone, with a small jar selling for $2–$3 USD (Ramos, 1998). More recently in a Mexican article, *agua celeste* was referred to as a mixture of solvents and ephedrine, a precursor used to manufacture methamphetamine that was recently banned in Mexico. This combination is then reportedly ingested and inhaled from soaked cloths (Chacon, 2007). An article from the Washington Post described *agua celeste* as a "cheap industrial solvent" (Booth and Fainaru, 2009). Although the exact formulation of *agua celeste* may have changed over time and may differ depending on which solvents are regionally available, repeated exposure to these agents can lead to short and long term health damage (Beaeza et al., 2009).

Mexico's 2008 National Household Survey reported that the national lifetime prevalence of *agua celeste* use was 0.83%, with all cases detected in the central state of Aguascalientes and northeastern state of Chihuahua (Secretaria de Salud, 2008). In Mexico City, 0.2% of high school students reported use of *agua celeste* (Villatoro et al., 2009), and an ongoing study of drug users in treatment who report use of *agua celeste* refer to its effects as similar to the euphoric effects of toluene but stronger (Ortiz, 2010). Use of a similar compound has been reported in other regions; 30% of 8th grade students in Leon, Guanajuato, (central Mexico) who were asked to list the different substances abused in their environment named "*agua de celaste*" (Enriquez Bielma et al., 2006).

The aims of the present study were twofold. First, we determined prevalence of lifetime and recent use of *agua celeste* within an ongoing study of FSW-IDUs in two northern Mexican cities. Second, we identified factors associated with lifetime and current use of *agua celeste* in this sample. Based on our findings, we suggest areas for future research that have implications for prevention and treatment.

2. Methods

2.1. Study setting

This study was conducted in Tijuana and Ciudad Juarez, Mexico, two cities along the Mexico–U.S. border with large populations of female sex workers. Tijuana is adjacent to San Diego, California and is the largest Mexican–U.S. border city. Tijuana and San Diego form the world's largest and busiest land border crossing (U.S. Department of Transportation, 2008). Ciudad Juarez is adjacent to El Paso, Texas and is the largest city in the Mexican state of Chihuahua. In 2000, 36% of Ciudad Juarez inhabitants were born outside of Chihuahua (U.S. Department of Transportation, 2008). In 2008, approximately 18% of FSWs from Tijuana and Ciudad Juarez reported ever injecting drugs, with a higher proportion of FSWs in Tijuana reporting recent injection drug use (15.8% vs. 8.7%, $p = 0.001$) (Strathdee et al., 2008).

2.2. Study population and sample

Between November 2008 and July 2010, FSW-IDUs from Tijuana ($N = 307$) and Ciudad Juarez ($N = 316$) were recruited using convenience sampling into a behavioral intervention study designed to reduce both high risk injection and sexual behaviors. Eligibility criteria included being ≥18 years of age; having had unprotected vaginal or anal sex with a male client at least once during the previous month; having shared syringes or injection paraphernalia (i.e. cookers, cotton, rinse water) at least once within the past month; ability to speak Spanish or English; ability to provide informed consent; and having no plans to move out of the city in the next 12-months. Trained, bilingual interviewers collected baseline data from all eligible subjects independent of their HIV status. Women were reimbursed $15 USD for their participation in the baseline interview. The Institutional Review Board of the University of California, San Diego and the Ethics Boards of the Tijuana General Hospital and Universidad Autonoma de Ciudad Juarez approved all study protocols.

2.3. Measures

We restricted this analysis to baseline data from this longitudinal intervention study. Participants underwent an interview-administered survey eliciting information on sociodemographics, sexual risk behaviors, injection risk behaviors, and experiences representing their physical, social, and economic environments in their lifetime and over the last six months. Sociodemographic questions included age, marital status, city of birth, migration history, sexual and physical abuse history, income and living arrangements. Questions on history of sexual behavior included age at initiation into sex work, reasons for entering sex work, and protected and unprotected sex acts with regular and casual clients and intimate partners.

Questions on history of drug use behaviors included age of first use and/or injection of specific drugs alone and in combination, sharing of injection equipment and drug use with clients. Two dependent variables guided the analysis. First, a single "yes/no" item asking participants if they had ever used *agua celeste* defined lifetime *agua celeste* use. Second, a follow-up question about the frequency of *agua celeste* use in the past 6 months was asked of all participants who reported "ever" using *agua celeste*. This multiple response item (never, once a month or less, 2–3 days a month, once a week, etc.) was then collapsed into a dichotomous outcome of "recent use" versus "no recent use".

2.4. Laboratory tests

The "Determine"® rapid HIV antibody test was administered to determine the presence of HIV antibodies (Abbott Pharmaceuticals, Boston, MA). All reactive samples were tested using an HIV-1 enzyme immunoassay and immunofluorescence assay at the County of San Diego, Public Health Laboratory. Those testing HIV-positive were referred to the local municipal health clinics in Tijuana or Ciudad Juarez for monitoring and care.

Syphilis serology used the rapid plasma reagin (RPR) test (Determine™ Syphilis TP). RPR-positive samples were subjected to confirmatory testing using the *Treponema pallidum* particle agglutination assay (TPPA) (Fujirebio, Wilmington, DE, USA) at the County of San Diego, Public Health Laboratory.

Initially, gonorrhea and chlamydia were detected using a rapid test kit (BioStar® OIA® GC and CHLAMYDIA) and positive samples were confirmed on urine specimens using APTIMA COMBO 2® Assay (Genprobe, San Diego, CA). However, upon release of recommendations from the U.S. Centers for Disease Control and Prevention that questioned the sensitivity of the Biostar rapid GC test, this test was discontinued on March 24, 2009. After this date, all participants provided urine for GC screening using a transcription-mediated assay (Genprobe, San Diego, CA). Samples were batched periodically and shipped to the San Diego County Health Department for confirmatory testing. Women with reactive STI tests were provided with free on-site treatment in accordance with U.S. and Mexican guidelines.