Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 91, No. 5
doi:10.1007/s11524-014-9899-y
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Correlation between Cocaine Prices and Purity with Trends in Emergency Department Visits in a Major Metropolitan Area

He Zhu, Fernando A. Wilson, Jim P. Stimpson, and José A. Pagán

ABSTRACT *Illicit drug use not only causes acute and chronic adverse health outcomes but also results in a significant burden to health care providers. The objective of this study is to examine the relationship between cocaine prices and purity with emergency department (ED) visits for the Chicago-Naperville-Joliet metropolitan area. Our primary outcome was number of cocaine-related ED visits per quarter provided by the Drug Abuse Warning Network. The predictor variables of cocaine purity and price were provided by the System to Retrieve Information from Drug Evidence database. Autoregressive integrated moving average (ARIMA) regressions were used to estimate the effects of cocaine price and purity on cocaine-related ED visits. Although cocaine prices did not change substantially over time, cocaine purity decreased by over 30 % between 2006 and 2010. ARIMA regression results suggest that cocaine-related ED visits were not significantly associated with powder or crack cocaine prices; however, a decrease in powder cocaine purity was associated with 2,081 fewer ED visits overall from 2007 to 2010. The cocaine trade continues to be a major public health and law enforcement threat to large metropolitan cities like Chicago. Regular monitoring of cocaine purity levels may provide early warning of impending changes in cocaine-related ED visits for law enforcement and health care providers.*

KEYWORDS *Cocaine, Emergency room, Drug abuse, Substance abuse, Illicit drugs, Economic factors*

INTRODUCTION

Illicit drug use not only causes acute and chronic adverse health outcomes but also results in a significant burden to health care providers.[1–4] Illicit drug use is estimated to result in over $11 billion in health care costs annually.[2] Cocaine is one of the most prevalent and addictive illicit drugs.[1,5] According to the National Survey on Drug Use and Health (NSDUH), about 4 million Americans aged 12 years or older used cocaine in 2011, accounting for 10 % of all illicit drug use.[6] Illicit drug use frequently results in visits to an emergency department (ED).[7–9] There are about 1

Zhu, Wilson, and Stimpson are with the Department of Health Services Research and Administration, College of Public Health, University of Nebraska Medical Center, 984350 Nebraska Medical Center, Omaha, NE 68198-4350, USA; Pagán is with the Center for Health Innovation, The New York Academy of Medicine, 1216 Fifth Avenue, New York, NY 10029-5202, USA; Pagán is with the University of Pennsylvania, Leonard Davis Institute of Health Economics, 3641 Locust Walk, Philadelphia, PA 19104-6218, USA.

Correspondence: He Zhu, Department of Health Services Research and Administration, College of Public Health, University of Nebraska Medical Center, 984350 Nebraska Medical Center, Omaha, NE 68198-4350, USA. (E-mail: he.zhu@unmc.edu)

million non-alcohol, illicit drug-related ED visits annually in the USA, and cocaine use is responsible for about half of these visits.[10]

Drug price and purity are important determinants for illicit drug use—and, consequently, for health services utilization—and for the magnitude of the pharmacological effect of the drugs used.[11–14] In recent years, a key debate in national drug policy and legislation has been whether drug abusers, especially heavy drug users, are responsive to changes in drug prices.[13–15] There is limited research examining the relationship between cocaine prices and ED visits.[11–13] Our study expands this literature in several ways. First, this study provides new evidence on the relationship between cocaine price and purity and ED visits for recent years. Second, the database used in prior studies—the Drug Abuse Warning Network (DAWN)—changed its methodology to improve data quality in 2004,[16] and to our knowledge, no study has examined cocaine price and purity using DAWN data since that change in methodology. Third, prior studies used illicit drug price data from the Drug Enforcement Agency's (DEA's) System to Retrieve Information from Drug Evidence (STRIDE) database,[11–14] which provides data on undercover drug purchases made by the DEA, including drug type, price, and purity.[17] However, STRIDE is not a nationally representative, random sample dataset and, thus, may not accurately represent national-level trends in illicit drug prices, limiting the usefulness of prior studies that relied on the STRIDE data.[17–19] Furthermore, there is a substantial geographic variation in drug markets and DEA stings.[19–21] We focus on the Chicago metropolitan statistical area (MSA) because it is the third largest MSA in the USA, one of the largest drug markets in the USA, and a major drug distribution hub.[22] For this reason, the cocaine market is expected to have a substantial impact on Chicago-area health care providers. In addition, the Chicago MSA has the highest number of cocaine-related ED visits among the MSAs in the DAWN database; Chicago's rate of cocaine-related ED visits per 100,000 population is double the national level (312 vs. 164).[10] Finally, we examine both crack and powder cocaine. The two forms of cocaine may have differing relationships with prevalence rates and ED visits across geographic areas and racial/ethnic groups.[23–25] Prior studies did not differentiate between crack and powder cocaine.[11–13] In this study, we examine the relationship between crack and powder cocaine prices and purities with trends in cocaine-related ED visits in the Chicago MSA.

METHODS

Data Sources

DAWN is maintained by the Substance Abuse and Mental Health Services Administration (SAMHSA), US Department of Health and Human Services, and is a public health surveillance system to monitor drug-related hospital ED visits.[26] DAWN includes misuse and abuse of illicit drugs and non-medical use of pharmaceuticals related to ED visits.[26] Hospital providers in DAWN are non-federal and have at least one 24/7 ED. In 2004, DAWN adjusted its survey methodology to improve the quality, reliability, and generalizability of its estimates; thus, 2004 is the earliest year in our study period.[16,26]

STRIDE is maintained by the DEA and records cocaine purchases by undercover drug enforcement agents. Drug purchases are tested in laboratories to determine potency.[17,18] Purchase data also includes transaction price and amount by weight.[17] A disadvantage of STRIDE data is that they are not obtained through probabilistic sampling of drug markets and, thus, do not represent the actual distribution of

prices and purities in illicit drugs in the USA.[18–20] We examined one market—the Chicago MSA (Chicago-Naperville-Joliet)—in order to mitigate this disadvantage. However, STRIDE price and purity data have been used in prior research and validated for specific geographic locations.[23–25,27] Furthermore, STRIDE data are likely to reflect the best information currently available on trends in cocaine prices and purity.[19]

We focused on ED visits within the Chicago MSA because this MSA is one of the largest drug markets in the USA in terms of the number of transactions within the STRIDE database.[22] The year 2010 was the most recent year available in STRIDE and, therefore, our study period includes 2004 to 2010. There were a total of 204,422 cocaine-related ED admissions in the Chicago MSA during the study period.[26]

Measures

An ED visit is identified as cocaine-related if cocaine use was recorded in DAWN. Cocaine-related ED visits were stratified by race/ethnicity and age. Racial/ethnic groups were classified as non-Hispanic white, non-Hispanic African American, and Hispanic. Race/ethnicity for other groups (such as Asian) was not provided by DAWN. Age groups included younger than 21, 21 to 34, 35 to 44, 45 to 54, and 55 years and older.

We examined price and purity data on cocaine purchases of 50 g or less. Price per gram substantially decreases with large drug purchases, and large purchases represent a small proportion of overall purchases.[13,18] Purchases of 50 g or less account for 65 % of total records in STRIDE. The median price per gram and average purity of these purchases were computed for both crack and powder cocaine for the Chicago MSA. The median price per gram was used instead of the mean price per gram to reduce the influence of outliers and to be consistent with prior research on illicit drug prices.[18] All prices were adjusted to 2010 dollars using the consumer price index.[18,28] Purity is defined as the percentage of pure cocaine in 1 g of a drug purchase.[18] Cocaine is commonly adulterated by various substances ranging from baking powder to potentially harmful or illicit substances such as benzocaine and levamisole;[29–32] therefore, a drug purchase will consist of less than 100 % pure cocaine. For example, the purity of powder cocaine ranged from nearly 5 to 95 % in the study period for the Chicago MSA.

Statistical Analysis

Quarterly data on cocaine prices, purity, and ED visits were examined from 2004 to 2010. The relationships between trends in ED visits and crack and powder cocaine prices and purities are presented. Autoregressive integrated moving average (ARIMA) models were used to estimate the impact of cocaine prices and purities on the volume of ED visits in the Chicago MSA. We identified the order of differencing and the numbers of autoregressive or moving average terms by checking for stationarity and examining the correlogram. An ARIMA (1, 1, 1) model was selected as it provided the best fit. Results were stratified by age and race/ethnicity. Stata 12.1 (Stata Corp, College Station, Texas) was used for all analyses.[28]

RESULTS

Table 1 describes the characteristics of cocaine-related ED visits in the Chicago MSA. From 2004 to 2010, there were a total of 204,442 cocaine-related ED visits, but annual ED visits decreased 26 % in this period (from 31,113 in 2004 to 23,020 in 2010). The number of cocaine-related ED visits per 100,000 population decreased from 336 in 2004 to 243 in 2010. The proportion of all non-alcohol, illicit drug-related ED visits that involved cocaine use fell from 61.3 % in 2007 to 42.0 % in 2010.

The majority of cocaine-related ED visits involved males (66 %), African Americans (70 %), and patients older than 35 years (70 %). African Americans contributed the most to the decrease in cocaine-related ED visits (about 3,000 visits), and cocaine-related ED visits of patients aged 21 to 44 years also decreased by about 50 % from 2004 to 2010. However, the share of cocaine-related ED visits in 2004–2010 among patients aged 55 years or more nearly tripled. Other race and age groups either experienced small declines in share of ED visits during the study period or were stable. Most of the decline in cocaine-related ED visits occurred after 2008; visits decreased by 23.8 %, from 30,667 in 2008 to 23,373 in 2009.

Figure 1 depicts the number of cocaine-related ED visits with crack and powder cocaine price per gram. The correlations between crack and powder cocaine prices per gram and cocaine-related ED visits were very low—0.12 for crack and 0.16 for powder. Over the study period, the average quarterly crack price per gram was $48.69 (SD 11.54) and the average quarterly powder price per gram was $40.53 (SD

TABLE 1 Characteristics of cocaine-related emergency department visits, Chicago MSA, 2004–2010

	2004	2005	2006	2007	2008	2009	2010
Overall cocaine-related ED visits							
ED visits	31,113	30,224	34,857	31,188	30,667	23,373	23,020
Rate per 100,000 population	336	326	375	334	327	248	243
Percent of ED visits that are cocaine-related out of all illicit drug-related ED visits, %	57.98	60.25	57.48	61.28	54.82	48.08	42.02
ED visits by sex, %							
Male, %	66.20	65.12	65.54	65.85	66.03	66.80	65.89
Female, %	33.80	34.88	34.46	34.15	33.97	33.20	34.11
ED visits by race/ethnicity, %[a]							
Non-Hispanic white, %	19.58	20.17	19.98	18.61	18.10	22.39	20.96
African-American, %	69.65	69.79	69.18	68.26	71.50	66.58	70.08
Hispanic, %	10.77	10.04	10.83	13.13	10.40	11.04	8.96
ED visits by age, %							
<21 years, %	2.85	3.22	3.27	3.04	2.85	2.74	2.66
21–34 years, %	27.31	24.79	24.22	21.51	19.58	19.77	19.81
35–44 years, %	39.73	38.75	37.23	36.62	34.56	33.11	30.75
45–54 years, %	25.81	28.03	29.18	31.56	34.18	35.29	36.13
≥55 years, %	4.29	5.20	6.09	7.28	8.83	9.09	10.64

Data Source: Drug Abuse Warning Network, United States Department of Health and Human Services

[a]Other race/ethnicity cannot be directly estimated. DAWN reports did not report other race/ethnicity and we do not include other races here

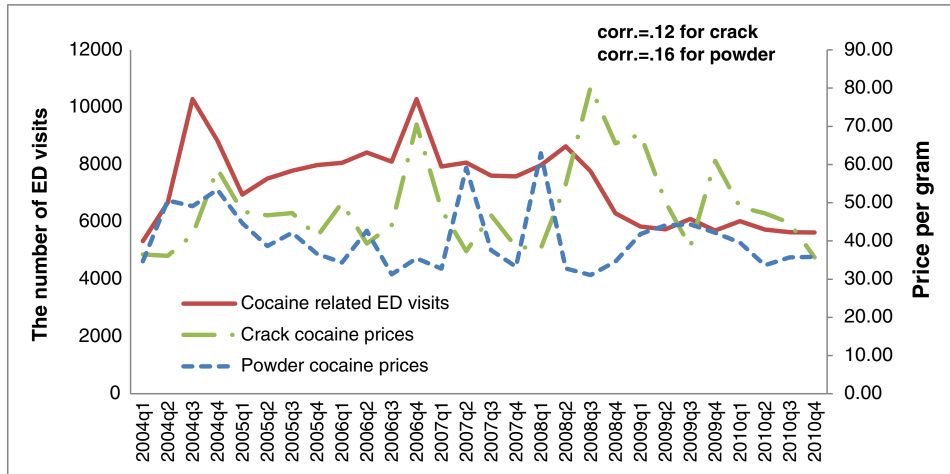

FIGURE 1. The number of cocaine-related ED visits and crack and powder cocaine price per gram, Chicago MSA, 2004–2010.

8.28). Prices per gram for crack and powder cocaine did not exhibit any clear time trend in the study period, although there was a high variation in crack and powder prices after the third quarter in 2006. In contrast, quarterly cocaine-related ED visits decreased from 10,282 in the fourth quarter of 2006 to 5,627 in the fourth quarter of 2010.

Figure 2 illustrates the trends of crack and powder cocaine purities and their relationships with cocaine-related ED visits. There was a positive association between trends in purities and ED visits; the correlation between average purity and ED visits was 0.54 for crack cocaine and 0.71 for powder cocaine. Average purities fell substantially from 2004 to 2010, decreasing from 69.1 to 50.5 % for crack cocaine and from 65.2 to 37.0 % for powder cocaine.

ARIMA regression results are provided in Table 2. Results suggest that cocaine-related ED visits were not responsive to changes in either powder or crack cocaine prices except for visits by Hispanics or persons younger than 21 years. In contrast,

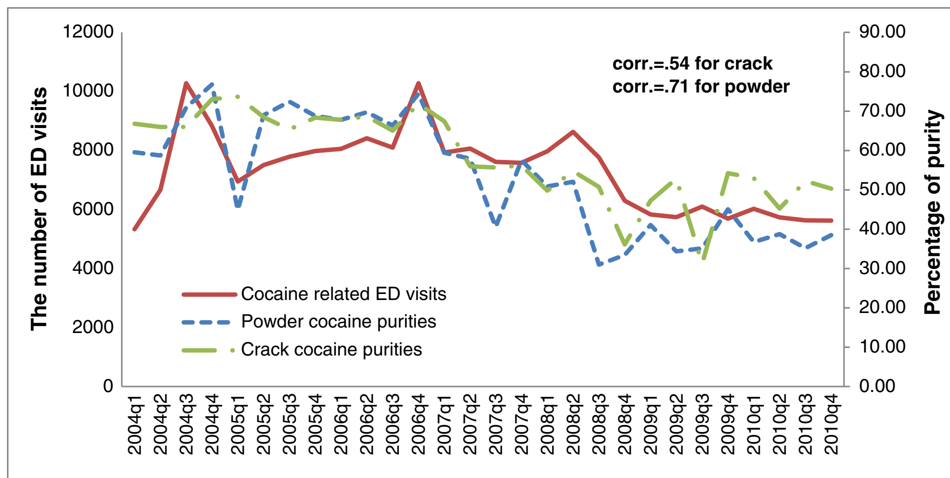

FIGURE 2. The number of cocaine-related ED visits and crack and powder cocaine purity, Chicago MSA, 2004–2010.

TABLE 2 ARIMA regression-predicted change in annual ED visits resulting from a $1 increase in crack and powder cocaine prices and a 10 % increase in cocaine purity level

	Inflation-adjusted price				Purity			
	Powder cocaine		Crack cocaine		Powder cocaine		Crack cocaine	
Outcomes	Effect size	*P* value	Effect size	*P* value	Effect size	*P* value	Effect size	*P* value
Overall number of cocaine-related ED visits								
Overall	54.24	0.324	106.24	0.167	2,312*	0.016	644.4	0.518
Rate (per 100,000 population)	0.56	0.329	1.16	0.164	24.8*	0.016	7.2	0.511
Number of ED visits by race/ethnicity								
Non-Hispanic white	22.96	0.578	89.8	0.078	269.2*	0.031	718.0	0.356
African American	−2.4	0.855	5.12	0.676	1,937***	0.001	197.6	0.630
Hispanic	10.08**	0.004	−6.76	0.304	−0.80	0.862	−37.2	0.710
Number of ED visits by age								
<21 years	3.96	0.073	5.72*	0.034	85.6	0.101	51.6	0.424
21-34 years	−3.4	0.823	7.64	0.671	690.4*	0.020	398.4	0.146
35–44 years	28.92	0.118	53.28	0.064	977.6*	0.013	329.6	0.506
45–54 years	11.08	0.601	33.8	0.155	760.8***	0.001	229.6	0.478
≥55 years	11.88	0.102	5.28	0.192	72.8	0.295	28.4	0.761
N	27		27		27		27	

*$p<0.05$; **$p<0.01$; ***$p<0.001$. Estimates from ARIMA (1, 1, 1) regression

powder cocaine purity had statistically significant relationships with the total cocaine-related ED visits and with visits stratified by race/ethnicity and age group. For example, the regression predicts that a 10 % increase in powder cocaine purity in 2010—from 38 to 48 %—would result in 2,312 more cocaine-related ED visits per year and an increase of 24.8 ED visits per 100,000 population. Among racial/ethnic groups, there would be 269 more ED visits for non-Hispanic whites and 1,937 more visits for African-Americans in a year. The ARIMA model also predicts that the increase in powder cocaine purity would result in 690 more cocaine-related ED visits per year for people aged 21 to 34 years, 978 more for those aged 35 to 44 years, and 761 more for those aged 45 to 54 years. The average powder cocaine purity decreased in Chicago after late 2006. The ARIMA regression model suggests that this decrease resulted in 2,081 fewer ED visits overall, almost 20 % of the average decrease from 2007 to 2010. Interestingly, crack cocaine purity did not have a statistically significant relationship with cocaine-related ED visits in the study period.

DISCUSSION

Cocaine use continues to be a major public health and law enforcement threat to the USA and to large metropolitan areas like Chicago. Interestingly, although inflation-adjusted cocaine prices did not change substantially over the study period, cocaine purity decreased by over 30 % after 2006. Cocaine purity is positively correlated with cocaine-related ED visits, and our findings suggest decreases in powder cocaine

purity were associated with significant declines in ED visits. In contrast, there was no statistically significant relationship between cocaine prices and overall ED visits in the Chicago MSA.

The significant relationship between powder cocaine purity and ED visits may be due to a number of factors. First, approximately 88 % of all cocaine-related ED visits were coded as powder cocaine by DAWN's drug classification system when slang terms or brand names for cocaine were reported by DEA agents (SAMHSA, personal communication).[26] This coding pattern may help explain why trends in ED visits were correlated more with powder cocaine than with crack. Second, powder cocaine's lower purity may reduce the magnitude of the adverse effect and the level of cocaine addiction. To increase the volume of cocaine and maximize profits, dealers may dilute pure cocaine with inert substances such as sugar, talcum powder, or cornstarch.[1,33,34] However, other adulterants—especially other illicit substances or over-the-counter products—may be toxic and contribute to adverse effects.[29–32] Third, the route of cocaine administration can produce different types and levels of adverse effects.[1,25] Prior research suggests that intranasal use of powder cocaine may significantly increase the risk of an adverse reaction and snorting cocaine usually has a longer-lasting effect than does smoking it.[1,25] In contrast, the lower level of purity and smoking route of administration for crack cocaine may help to understand the statistically insignificant relationship between crack cocaine and ED visits in the Chicago MSA.

The relationship between drug prices and drug use has important implications for drug policy.[11,12,15] The relevant question is whether prices affect use. Previous studies have shown significant increases in ED visits as cocaine prices fell in the 1980s and 1990s.[11,12] However, we did not identify a significant relationship between cocaine prices and ED visits in the Chicago MSA. This contradictory result may stem from the changing context of drug supply. In an analysis of Chicago's drug market, the National Drug Intelligence Center argued that although cocaine availability has decreased significantly, two-thirds of law enforcement agencies in the Chicago area reported a high availability of either powder or crack cocaine in their jurisdictions.[35] This analysis implied that cocaine has a relatively sufficient or stable supply market in the Chicago area. Also, the degree of competition in cocaine and other illicit drug markets seems to have increased over time.[15] Both stable supply and increased competition among dealers may contribute to the small fluctuations in cocaine prices and the insignificant relationship between price and ED visits.

In the Chicago MSA, the number of cocaine-related ED visits decreased every year from 2006 to 2010, a finding that is consistent with trends in drug use in Illinois recorded in the NSDUH. The number of cocaine users dropped 27 % (by 68,000 users) in Illinois from 2006 to 2010.[36] Yet prior research on national trends showed no such decrease in cocaine-related ED visits.[26]

To help validate our examination of trends in cocaine prices and purities, we compared data from the Chicago MSA with national-level trends. We found similar trends for cocaine price and purity in Chicago and nationally. However, in 2010, cocaine prices and purity levels in Chicago were significantly lower than they were nationally—40 % in Chicago versus 48 % nationally.[37]

Neither our study nor previous studies found a consistent relationship between drug prices and ED visits. However, our results suggest that regular monitoring of cocaine purity can provide important feedback to law enforcement and health care providers. Drug dealers may respond to changing drug market and law enforcement pressure by manipulating cocaine quality rather than by adjusting prices. For

example, powder cocaine purity decreased by one-third during the study period. In contrast to trends in purity, inflation-adjusted cocaine prices remained relatively stable. According to an ethnographic report, high law enforcement pressure leads to decentralization in drug organizations and consequently smaller volume drug sales, which may correlate with increasing adulteration of the illicit drug.[32] Monitoring of cocaine purity may help identify locations at risk for increases in cocaine-related ED visits and, thus, resources can be targeted to these areas to improve outreach, education, and other prevention efforts as well as drug treatment activities.

The current US drug control strategies are moving to prevent drug use and increase access to addiction treatment, whereas previous drug control strategies emphasized restraining the supply.[37,38] In addition, most illicit drug ED visits involve drugs with various adulterants or multiple drugs, a phenomenon which could create new challenges for the health care system and society.[10,26]

LIMITATIONS

There are several limitations to this study. First, STRIDE is an administrative database of the DEA and was not collected by probabilistic sampling. Therefore, it is difficult to determine whether prices and purities accurately reflect market conditions for illicit drugs. We anticipate that our focus on the Chicago area may mitigate this limitation relative to a national-level analysis. However, results for the Chicago market may not be generalizable. For instance, African-Americans account for over half of cocaine-related ED visits in Chicago MSA, which may be different from other MSAs and also in comparison to other drugs. Second, data on patients' socioeconomic status are not available, and we have no information on the supply of other illicit drugs in the region. These missing data may impact the results. Finally, we cannot differentiate between crack or powder cocaine specific ED visits using DAWN, which may under or overestimate the effects of crack and powder cocaine.

CONCLUSIONS

This study used an administrative database of undercover illicit drug transactions by the DEA to examine the relationship of trends in cocaine prices and purity on cocaine-related ED visits for a major metropolitan area in the USA. There is little evidence that ED visits are significantly impacted by changes in cocaine prices. However, regression analysis suggests a significant association between declining trends in cocaine purity and decreases in ED visits related to cocaine use.

FUNDING. NO FUNDING TO DISCLOSE.

Human Subjects. This research is based on public use data files that were approved by the appropriate institutional review board.

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