Methadone Dosing, Heroin Affordability, and the Severity of Addiction

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ABSTRACT

Objectives. This study sought to track changes in US heroin prices from 1988 to 1995 and to determine whether changes in the affordability of heroin were associated with changes in the use of heroin by users seeking methadone treatment, as indexed by methadone dose levels.

Methods. Data on the price of heroin were from the Drug Enforcement Administration; data on methadone doses were from surveys conducted in 1988, 1990, and 1995 of 100 methadone maintenance centers. Multivariable models that controlled for time and city effects were used to ascertain whether clinics in cities where heroin was less expensive had patients receiving higher doses of methadone, which would suggest that these patients had relatively higher physiological levels of opiate addiction owing to increased heroin use.

Results. The amount of pure heroin contained in a $100 (US) purchase has increased on average 3-fold between 1988 and 1995. The average dose of methadone in clinics was positively associated with the affordability of local heroin ($P < .01$).

Conclusions. When heroin prices fall, heroin addicts require more methadone (a heroin substitute) to stabilize their addiction—evidence that they are consuming more heroin. (*Am J Public Health.* 1999;89:662–665)

Heroin addiction has major medical, social, and economic implications. Use of heroin and other illicit drugs is a causal factor in the development of a number of diseases[1–3] and has been implicated as a major cause of crime: in 1994, roughly 66% of all arrestees in the United States tested positive for an illicit drug at the time of their arrest.[4] Prevention or reduction of heroin addiction could attenuate these medical and social consequences. To this end, politicians, policy analysts, health care providers, and advocacy groups have proposed a range of approaches.

One approach aims to raise the cost to the individual of selling or purchasing an illegal drug[5]; this approach includes efforts to expand local law enforcement, increase penalties for selling or possessing illegal drugs, and heighten international drug interception. In 1991, the last year for which figures are available, local, state, and federal agencies devoted approximately $18.9 billion to such efforts.[6,7] Given this strategy, it would be helpful to have a better understanding of the consequences of changes in price for addicts, drug treatment providers, and society in general.

In theory, changes in price can lead to a number of different changes in patterns of use. Saffer and Chaloupka have shown that relatively small changes in the affordability of drugs lead to relatively large changes in "casual use" of heroin, cocaine, and marijuana.[8] In addition, Kleiman and Caulkins have argued that lower heroin prices encourage current users to share drugs and thereby recruit new users.[9] Lower prices are associated with greater purity of heroin, and Boyum et al. have suggested that increased heroin purity encourages use by making intranasal use more feasible.[10] Many also believe that price has little impact on the large population of people who are already "hard-core addicts."[6,11]

In this article, we examine the affordability of heroin in the United States over the years 1988 through 1995 and propose a model by which we can measure the consequences of price changes over these years on heroin consumption by treatment-seeking addicts. We also discuss the relationship between recent changes in methadone treatment doses and recent changes in heroin prices. Attention to these issues should help to improve our understanding of the epidemiology of heroin addiction and determine to what extent further efforts aimed at raising the price of heroin are likely to be effective in deterring heroin use.

Methods

Data

The Drug Enforcement Administration (DEA) conducts a surveillance program (the Domestic Monitor Program [DMP]) to monitor the retail market for heroin. The program, which has been described elsewhere,[10] uses drug informants and undercover DEA agents to make retail purchases of heroin on the street (C. Hoffman and C. Heilig, DEA

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Note. The analyses and interpretations of the data in this article are the sole responsibility of the authors, and do not represent the views of either their institutions or the Robert Wood Johnson Foundation.

Statistical Unit, oral communication, 1996). The informants (or agents) are instructed to purchase a specific retail amount and to negotiate the best possible purchase price and quality. The purchases are then returned to the DEA's Washington, DC, area laboratory for analysis.[12] We used data on 3894 purchases to determine the amount of pure heroin an addict would receive for $100 (in 1995 dollars) in a particular city in a particular year.

We used a proxy measure for the amount of heroin consumed by addicts at a particular time in a particular city: the average stabilization methadone dose for addicts entering treatment at that time in that city. This dose reflects the methadone dose at which the addict is maintained, usually after a 2- or 3-week period during which doses are regularly increased. We used the stabilization dose as a proxy measure of addicts' heroin consumption before entering treatment, as methadone doses are adjusted to alleviate the addict's craving and withdrawal symptoms and to induce tolerance to opiates. Therefore, addicts who regularly consume a larger amount of heroin will require a larger amount of methadone when stabilized in treatment.[13–15]

D'Aunno and Vaughn, at the Institute for Social Research (ISR), conducted a nationwide survey of methadone treatment providers in 1988, 1990, and 1995.[16] The study was conducted on an initial sample of providers in 1988 and follow-up surveys in later years were sent only to those who had responded to the previous poll. This survey included questions about the average stabilization methadone dose reached by clients after entry into treatment. It also included questions about the clinic's funding source, staffing, treatment philosophy, patient population, and percentage of patients receiving steadily decreasing doses of methadone.

We used these data to determine the average dose of methadone used in clinics in DMP cities. We linked the average clinic methadone doses to local measures of the price and purity of heroin from the DEA data, and we included clinics that were within 3 counties of one of the DMP cities.

Statistical Analysis

Statistical analyses were performed with Stata software (Stata Corp, College Station, Tex). All reported *P* values are 2-sided. Summary price data are arithmetic means based on all retail transactions. Drug prices are adjusted to 1995 dollars on the basis of the Bureau of Labor Statistics Urban Consumer Price Index.[17] Differences in methadone doses over time were assessed by one-way analysis of variance. Weighted least squares multiple regression analysis with methadone clinics as the unit of analysis and weights based on the number of patients treated in the clinic, was used to fit a linear equation for the relationship between the average methadone dose and the amount of pure heroin available for $100. Three models of the effect of price on dose are presented:

1. Model A (across cities) uses 0–1 variables for the year of the survey and ascertains whether differences in the amount of pure heroin available for $100 in different cities explain differences in methadone doses across cities.
2. Model B (across time) uses 0–1 variables for each city and ascertains whether differences in the amount of pure heroin available for $100 in different time periods explain differences in methadone doses across time periods.
3. Model C (within treatment center) has as its dependent variable the change in average methadone dose in a particular clinic from 1988 to 1990 or from 1990 to 1995, and has as its predictor the change in the amount of heroin available for $100 in that city over the same time period.

Models A and B also control for clinic factors found to influence methadone dose in previous studies: the clinic's (a) for-profit status; (b) Midwest or non-Midwest location; (c) mental health treatment capacity; (d) percentage of African American patients; and (e) percentage of patients on steadily decreasing doses of methadone.[16]

We performed additional analyses beyond those listed above, which yielded similar results. In particular, we analyzed only clinics that did not eventually drop out of the survey; used a random-effects model for each clinic or each city; specified a log–log relationship between average dose and average affordability; estimated robust standard errors while allowing for clustering effects within clinic or within city; and used a model that controlled for both city and time fixed effects while accounting for clustering of clinics within cities.

TABLE 1—Average Amount of Heroin (mg) Available in 10 US Cities for $100 (in 1995 Dollars), 1988–1995

	1988	1989	1990	1991	1992	1993	1994	1995
Atlanta	29.2	59.6	28.7	49.9	70.3	63.4	82.5	76.9
Chicago	30.3	64.5	39.4	49.4	99.7	192.6	112.7	121.1
Washington, DC	NA	NA	45.7	65.2	50.0	104.1	80.5	106.0
Detroit	67.0	83.4	76.7	69.6	71.5	85.4	96.3	102.6
Los Angeles	76.7	104.9	97.1	92.8	166.8	221.1	282.3	267.1
Miami	NA	NA	17.5	17.2	49.2	86.2	80.6	122.0
New York	106.6	74.1	102.7	152.9	208.4	241.5	267.0	318.2
Philadelphia	NA	NA	NA	96.9	171.7	219.1	229.3	315.3
Phoenix	51.3	109.7	86.2	52.3	60.2	53.0	115.7	244.3
San Francisco	NA	NA	86.1	44.9	109.5	87.1	137.7	195.6

Note. NA = not available.

Sample

We used all available data to estimate the above models. For models A and B, we used 182 observations generated from 100 clinics surveyed in 1988, 1990, and 1995 in 21 US cities. For model C, we used 84 observed changes in methadone doses generated from 55 clinics in 13 US cities. The cities in our sample include all cities in which the DMP is actively collecting heroin price data and the Institute for Social Research is conducting research on methadone treatment. These cities represent 21 of the 50 largest cities in the United States, including 8 of the 10 largest cities. The 21 cities are Atlanta; Baltimore; Boston; Chicago; Dallas; Denver; Detroit; Los Angeles; Miami; Newark, NJ; New Orleans; 3 boroughs of New York City; Philadelphia; Phoenix; San Diego; San Francisco; Seattle; St. Louis, Mo; and the District of Columbia.

Results

Amount of Pure Heroin Available for $100

Table 1 shows the amount of pure heroin available on average for $100 (in 1995 dollars) in a representative sample of cities for the years 1988 through 1995. The data exhibit 2 important patterns. First, there is a great deal of variability across cities in the amount of pure heroin available for $100. For example, in 1988, $100

TABLE 2—Impact of the Amount of Pure Heroin Available for $100 (in 1995 Dollars) in 1988, 1990, and 1995 on the Average Dose of Methadone in a Methadone Maintenance Clinic

Factor	Model A (Across-City Model)[a] Impact on Methadone Dose (mg)	*P*	Model B (Across-Time Model)[a,b] Impact on Methadone Dose (mg)	*P*	Model C (Within-Clinic Model) Change in Methadone Dose (mg)	*P*
Price of heroin						
Amount of heroin available for $100	+ 0.03	.001	+ 0.04	<.001		
Change in amount available for $100					+ 0.03	.007
Year variables[c]						
1988 → 1990	+ 0.69	.73				
1988 → 1995	+ 2.5	.35				
Constant	+ 49.9	<.001	+ 52.6	<.001	+ 3.1	.05
df	(8, 171)		(26, 153)		(1, 81)	
R^2	.41		.56		.09	

[a]Models A and B control for clinic factors important in methadone dosing (for-profit status, percentage of Black patients, percentage of patients on decreasing doses of methadone, availability of mental health treatment).
[b]City effects for 21 cities controlled for but not reported.
[c]Referent year is 1988.

bought 29 mg of pure heroin in Atlanta, while in Los Angeles, an addict received 77 mg of pure heroin for the same amount of money. These differences tend to persist over time.

Second, there are very strong trends after 1990 in the affordability of heroin. An addict could purchase much more pure heroin for $100 in 1995 than in earlier years. For example, $100 would buy 318 mg of heroin in New York in 1995, an increase of 200% over the amount that could be purchased in 1988 for the same amount of real dollars (107 mg). In Phoenix, affordability increased by 375% over the same time period. In fact, the amount of pure heroin available for $100 at least doubled over this time period in all markets under observation except one (Detroit), which experienced a 53% increase.

Average Dose of Methadone in a Methadone Maintenance Clinic

Methadone doses in the DMP cities rose from 47 mg/day in 1988 (range, 27 mg per day to 75 mg per day) to 48 mg/day in 1990 (range, 24 mg to 68 mg) to 58 mg/day in 1995 (range, 27 mg to 83 mg) ($P < .001$ for differences across time). These results are similar to those found by D'Aunno and Vaughn in their follow-up surveys of methadone clinics (T. D'Aunno, unpublished data).

Relationship of $100 Heroin Dose to Methadone Dose

Table 2 shows the results of 3 regression analyses. In each analysis, the general question being tested is, Does the amount of heroin locally available for $100 have an impact on local methadone doses? In the model A column, we report the coefficients on the year categorical variables 1988 to 1990 and 1988 to 1995 after we controlled for the effect of the changing price of heroin. We do not report the city effects incorporated in the estimation of model B or the clinic characteristics incorporated in the estimations of models A and B.

The results of these 3 analyses all support the same conclusion: There is a strong positive relationship between the affordability of heroin and the average stable methadone dose. Model A provides evidence that, with time held constant, differences in heroin affordability explain differences in methadone doses across cities (coefficient = .03, $P = .001$). Model B provides evidence that, with location held constant, changes in the affordability of heroin over time are associated with changes in methadone dosing over time (coefficient = .04, $P < .001$). Although it has limited explanatory power, model C provides evidence that changes in heroin affordability are directly associated with the degree of change in methadone doses in individual clinics (coefficient = .03, $P = .007$).

Have Falling Heroin Prices Contributed to a Rise in Methadone Doses?

Our analyses also suggest that much of the increase in methadone doses that we observed over time is due to changes in the heroin market itself. Specifically, the "1988 → 1990" and "1988 → 1995" variables in model A measure the change in methadone dose that occurred between 1988 and 1990 (0.69 mg) and between 1988 and 1995 (2.5 mg) that is not explained by changes in the affordability of heroin. Although the estimates for these trends are positive, they are not statistically significant ($P = .73$ and $P = .35$, respectively). Similarly, the constant term in model C reflects the increase in methadone dose that occurred, on average, between the 2 time periods—1988 to 1990 and 1990 to 1995—calculated with the effect of falling heroin prices controlled. This coefficient is greater than zero, but there is evidence that it is not equal to zero only at the lowest threshold of significance (3.1 mg, $P = .05$). Finally, a regression that included heroin affordability, clinic, city, and date effects (data not shown) fit the data no better ($P = .82$) than model B (which includes all but the date effects), suggesting that once we account for these other factors, the year of the survey has no discernible association with methadone doses.

Discussion

We found that when heroin becomes more affordable, we are likely to see an increase in the amount of methadone that addicts are receiving—an increase that presumably reflects their greater opiate dependence. This finding suggests that lower prices do, in fact, lead to more heroin use by addicts, and it supports the conclusion that efforts to raise heroin prices are based on a reasonable assumption: increasing the price will decrease use.

We also found that heroin prices fell over the years 1988 through 1995. Because of the apparent relationship between the price of heroin and heroin consumption, we postulate that in an environment of falling prices, addicts will suffer more profound acute morbidities, such as craving and withdrawal symptoms. As these morbidities become more

severe, addicts may be more likely to commit property crimes and engage in prostitution and other risky behaviors in order to "get a fix." Hyatt and Rhodes found that falling cocaine prices over the period 1981 through 1991 were associated with an increase in emergency room visits related to cocaine use and a higher prevalence of cocaine use among arrestees.[18] Lack of caution by desperate drug users, coupled with increased law enforcement efforts, may also increase the likelihood that drug users will be arrested and ultimately incarcerated. We do not have data pertaining specifically to heroin, but during the years of our study, arrests for possession of illegal drugs rose by 32% from 1988 to 1995.[19,20] Years of incarceration for persons convicted of drug possession rose by 15% (to 70 000 person-years) from 1990 to 1994.[21,22]

Our analyses have several important implications for health care providers caring for addicted individuals. First, previous studies in the United States suggest that treatment centers do not, in general, provide adequate doses of methadone to their clients.[16,23,24] Our analyses suggest that some of the variation observed between clinics and over time is explained by differences in opiate consumption—differences that are related to the local affordability of heroin. Second, in the context of falling heroin prices, we expect that treatment will be less efficacious if increased levels of opiate dependence are not fully appreciated, or if treatment centers follow dosing guidelines devised at a time when heroin was more expensive. To confront this problem, we echo the recommendations of numerous other authors who encourage providers to titrate methadone to a dose adequate for the individual patient in treatment.[25,26]

Finally, substantial effort and resources have been directed toward "the War on Drugs." This policy has 2 objectives: to reduce illegal drug use and to reduce the harm caused by illegal drug use. Most would agree that these efforts have not yielded good results to date. We believe that a better understanding of the relationship between heroin prices and heroin use is an important element in the development of a rational drug policy.

Limitations

Our study has several limitations. First, the DEA data capture only the *dollar* cost of heroin; as pointed out by Moore,[27] policy analysis should focus on the *effective* cost of heroin—a composite of dollar price and other costs, such as the time it takes to find a dealer or the risk of arrest or HIV infection. Second, because we observed only the average price and the average dose at moments in time, we based our conclusions on the very strong association we discovered between the affordability of heroin and methadone dosing, combined with a putative model of heroin addiction. Third, our results may be biased if city-level factors are correlated with both methadone doses and heroin prices; if methadone dosing strategies for intranasal users in the clinics in our sample were meaningfully different from those used for injecting users; or if there were significant changes during the years of our study either in the demographics of heroin users or in their reasons for seeking treatment. We also cannot account for treatment providers' raising methadone doses in an attempt to prevent patients from "shooting over" with heroin of increasing purity. Further studies should address these issues. Finally, we should emphasize that our model measures the intensity of heroin consumption by addicts. It does not measure the number of people using heroin at a particular time. □

Contributors

P. B. Bach and J. Lantos planned the study, analyzed and interpreted the data, and wrote the paper. Both authors are guarantors for the integrity of the research.

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