

**AN EXPLORATORY STUDY EXAMINING THE
SPATIAL DYNAMICS OF ILLICIT DRUG
AVAILABILITY AND RATES OF DRUG USE***

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ABSTRACT

This study examines the spatial relationship between drug availability and rates of drug use in neighborhood areas. Responses from 16,083 individuals were analyzed at the zip code level ($n = 158$) and analyses were conducted separately for youth and adults using spatial regression techniques. The dependent variable is the percentage of respondents using drugs in the past year. Neighborhood drug availability (the major independent variable) was measured by the percentage of non-drug users who had been approached to purchase drugs. Data were obtained as part of the Fighting Back community evaluation. For youth (aged 12 to 18), drug sales in adjacent and surrounding areas were positively associated with self-reported drug use in areas where youth were residents. For adults, drug sales within the neighborhood were negatively associated with drug use, while drug sales in immediately adjacent

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neighborhoods were positively related to self-reports of drug use. Findings suggest that the areas where rates of drug users are greatest are not necessarily the same area where drugs are sold. Designing strategies to reduce the supply of drugs should receive input from city and regional planners and developers, as well as law enforcement and public health professionals.

INTRODUCTION

The most naïve approach one can take to understanding the relationships of illegal drug access to illegal drug use is to consider drug use as directly related to access. One could assert that the proximity of individuals to illegal drug markets would be directly related to their: a) access to those drugs; b) opportunity costs of obtaining drugs; and c) use of these drugs. What makes this approach naïve is that it ignores the manifold determinants of both drug supply (e.g., policing activity) and demand (e.g., normative supports for use), the effects of which could mitigate, or eliminate, the connection between access and use. An alternative approach to understanding the relationship of illegal drug access to illegal drug use is to consider each as partially reflecting the other in the complex dynamics of community systems (e.g., including policing activities and norms against use). Presumably, illicit drug markets would not exist without demand, nor would the demand for illicit drugs exist without the drugs supplied by the markets.

To develop this perspective, we take a community systems approach that says the distribution and sales of illicit drugs directly affect rates of consumption (or use) of illicit drugs [1, 2]. The current study examines how the geographic location of the public distribution and sales system is related to the drug consumption system. By developing a greater understanding of this relationship, prevention efforts can begin to be targeted more effectively in communities to reduce the supply of drugs.

Due to the illegal nature of drug sales and use, prevention mechanisms developed to reduce alcohol misuse and related problems at the community level cannot be readily employed to prevent or decrease drug use and related problems. Current efforts to reduce drug sales in communities have relied upon increased law enforcement in areas where drug transactions are likely to occur and on tougher sanctions for those found guilty of selling drugs, yet these approaches have had limited success [3]. Therefore, alternative strategies that regulate distribution and sales through informal mechanisms may be an effective way to prevent drug use and related problems.

In order to develop more effective prevention strategies, there is considerable value in exploring the ways in which the geographic patterns of drug use are related to geographic patterns of drug access. Are residents of neighborhoods in which drugs are sold also likely to be drug users? Are these residents less likely to be drug users than residents of other community locations? As in the case of alcohol, do residents of wealthier areas travel to low income areas to purchase

illegal drugs? Answers to these essentially descriptive questions provide impetus to examine illegal drugs and drug markets from a new perspective; that of assessing the spatial dynamics of drug access, use and problems in community settings.

Current research providing background for answering these questions has found that drug sales are often concentrated in neighborhoods with higher levels of economic disadvantage, greater population density, and higher concentrations of minority residents [4-6], yet residents of impoverished neighborhoods experience levels of drug dependency at rates similar to that of those in wealthier areas [5, 7].

The current study examines the spatial relationship between drug availability and drug use separately for youth and adults to establish how drug activity is related to rates of drug use controlling for socio-demographics and drinking behaviors. By doing so, we can begin to discern some useful information about where drug users live versus where drugs are readily available. The knowledge of illicit drug availability by non-users enables researchers to begin to understand the level of overall community risk for drug related problems and help explicate the community systems in which interventions can be developed to reduce access to and the availability of illegal drugs.

METHODS

Data were obtained in 1991 to 1993 from the Fighting Back community evaluation sponsored by the Robert Wood Johnson Foundation.¹ This evaluation was conducted to assess the impact of community-wide intervention programs aimed at reducing alcohol and drug use. As part of the evaluation, a general population survey was conducted that included telephone interviews with persons from 21 communities, 20 of which were urban metropolitan areas. Unlike the other communities the twenty-first community was rural and therefore not included in the analysis. The use of older data is appropriate unless one believes that large-scale changes have taken place in drug availability and use patterns in urban areas over the past 10 years. There is no evidence that this has been the case. Though modest changes in usage levels have occurred, there has been remarkable stability in the levels and patterns of use of major illegal drugs (e.g., marijuana and cocaine) across urban areas [8, 9].

Households were selected using random digit dialing techniques. For the adult survey, one respondent aged 19 or older was selected randomly from each household, while for the youth survey, one respondent aged 12 to 18 was selected on the basis of the birth date nearest to the date of the survey contact. Youth were oversampled to obtain more precise estimates in this group. Interview response rates were 67% for adults and 70% for youth. The total number of respondents

¹ The authors will provide copies of the survey upon request.

was 16,083 and included 7,058 females and 9,025 males. In addition, there were 7,940 whites, 5,338 African Americans, 1,602 Hispanics, and 1,203 respondents of racial or ethnic backgrounds.

The zip code is the geographic unit of analysis for the current study. There were 198 original zip code areas with one or more youth and 200 with one or more adult respondents. Focusing upon the youth data, in order to obtain a minimum number of 10 subjects per zip code area, areas with fewer than 10 subjects were combined with adjacent zip code areas with which they shared the largest boundary. The zip code areas combined for youth were also combined for the adults yielding the same 158 combined zip code units. The average number of respondents in the combined zip code units was 39.9 for youth and 59.9 for adults. In the combined zip codes, the number of youth respondents ranged from 10 to 164, while the number of adult respondents ranged from 7 to 197.

Dependent Measure

Illegal drug use was ascertained by asking respondents whether they had used illegal drugs in the past year. The drug use items were formulated on the basis of standard items taken Monitoring the Future [10] and have previously been shown to be reliable [11]. Illegal drug use was measured as the percent of individual respondents who had used any illegal drugs in the past year. For these endogenous variables, cells with values of zero were corrected to values of $.5/n$ and cells with values of 1.0 were corrected to $1-.5/n$ (with n equaling the number of observations within cells.) After this correction, the endogenous variables were logit transformed, $\ln(p/(1-p))$ to provide normally distributed outcome measures. The proportion of youth who are drug users in neighborhood areas is twice that of adults (.15 vs. .07).

Independent Measures

The survey obtained self-reports for a number of domains. Information used for the current study include alcohol use, availability of illegal drugs, and demographic information such as age, gender, marital status, income, education, current employment status, and race/ethnicity. Only adult respondents reported on marital status, family income, employment, and education. When the data were aggregated into geographic units, this demographic information obtained by adults was applied to the analyses of the youth living in the same geographic unit. Both for youth and adults, the proportions of gender and ethnic group in the sample were weighted based on 1990 Census data to make their proportions in the sample equal to their proportions in the U.S. population.

All individual-level data were aggregated within geographic units. For the demographic measures, this created measures of percent young (i.e., percent youth respondents relative to all respondents), percent households with incomes below \$20,000, percent households with incomes above \$60,000, percent

unemployed adults, percent black, percent Hispanic, percent adults with any college education, percent male, and percent single. Population density (number of people/area) was based on the 1990 census and was obtained for each geographic unit. Table 1 provides the descriptive statistics for all respondents, separate for youth and adults. These tables show that there are higher proportions of male, African American, and Hispanic respondents among the youth than adults in these neighborhood areas.

The drinking measures were used to obtain the percent of abstainers and, among alcohol users, the average frequency of drinking, average drinks per occasion, and average variance in drinking quantities. Quantity-frequency information on alcohol consumption was obtained from a series of questions that began by asking the respondent whether they had consumed a full drink of alcohol at any time in the preceding 12 months. Alcohol consumers were then asked on how many days in the past 28 they had 1 or more, 2 or more, 3 or more, and 6 or more drinks. Infrequent drinkers, those who had consumed alcohol in the past year but not in the past month, were asked the same series of items about the preceding 365-day period and the responses were rescaled to a 28-day equivalent metric. Using answers to these questions, 28-day estimates of average drinking frequencies and quantities were obtained along with an estimate of the variance in drinking quantities over the 28-day period. The latter measure indexes the degree to which quantities consumed vary substantively over time, often indicating heavy drinking not reflected in the measure of average drinking quantity. Quantity-frequency measures of alcohol use, those here, have good reliability, meeting or exceeding test-retest correlations of $r = .70$ or better [see 12, 13]. The proportion of adults who were current drinkers was .65 compared to only .40 of youths.

Illegal drug availability was ascertained by asking respondents whether they had been personally approached for illegal drug sales in their neighborhood in the previous six months. Illegal drug availability was measured by the percent of illegal drug non-users who were personally approached for illegal drug sales in the preceding six months in each zipcode. The correlation between reports of approaches for drug sales between users and non-users was $r = .97$. Data from non-users were used because drug users reports would be inflated as a function of their own drug seeking behavior (since the use of drugs causes seeking for drugs). The more “passive” measure was expected to be more local and less “reactive” to the drug seeking state of the respondents. The proportion of youth approached for drug sales was higher than that for adults (.15 vs. .08).

Data Analysis

Series of spatial regression models are conducted separately for the youth and adult samples using Spatial Statistical System [14]. Spatial regression models are used because, within any given community, every geographic unit shared a contiguous boundary with at least one other unit. As such, if the process studied

Table 1. Descriptive Statistics of Aggregated Data at the Zip Code Level for All Respondents

Variable:	Mean	Min.	Max.	SE
Proportion drug users				
Youth	0.1472	0.0147	0.5077	0.0602
Adults	0.0704	0.0051	0.4024	0.0324
Proportion young				
Youth (12-15)	0.5948	0.2750	0.9407	0.0867
Adults (19-34)	0.3769	0.1548	0.5449	0.0684
Proportion Hispanic				
Youth	0.0664	0.0000	0.5000	0.0481
Adults	0.0463	0.0000	0.3595	0.0350
Proportion Black				
Youth	0.4025	0.0000	1.0000	0.0612
Adults	0.3235	0.0000	1.0000	0.0499
Proportion male				
Youth	0.4931	0.1110	0.8401	0.0882
Adults	0.4652	0.3647	0.2499	0.0703
Proportion drinkers				
Youth	0.4021	0.1000	0.7059	0.0857
Adults	0.6527	0.3125	0.6086	0.0665
Average frequency				
Youth	2.1055	0.0767	6.4228	0.4571
Adults	4.7228	0.4609	10.8724	0.8823
Average drinks per occasion				
Youth	1.8968	1.0000	3.5492	0.2260
Adults	1.8880	1.2314	1.5228	0.1913
Average variance				
Youth	1.9538	0.0000	8.3892	0.6669
Adults	1.6880	0.2446	4.5496	0.5769
Proportion approached for sales				
Youth	0.1539	0.0000	0.4583	0.0637
Adults	0.0841	0.0000	0.5078	0.0376
<u>Adult Only Variables</u>				
Proportion low income (<\$20,000)	0.4043	0.0000	0.9295	0.0677
Proportion high income (>\$60,000)	0.2736	0.0000	0.9095	0.0617
Proportion unemployed	0.0667	0.0000	0.5304	0.0355
Proportion some college	0.4963	0.1231	0.7823	0.0686
Proportion single	0.2719	0.0000	0.7055	0.0623

is a spatial one, as may be the case with the use and availability of illegal drugs, it is expected that contiguous spatial units will not be independent. That is, when analyzing data from these units with an ordinary least squares regression model, there will likely be some degree of spatial autocorrelation, data from units will appear similar, causing an increase in Type I errors. In case of negative spatial autocorrelation, data from the units will appear dissimilar, causing an increase in Type II errors. These effects of spatial autocorrelation can be controlled through the use of an appropriate maximum likelihood estimator that corrects for the extent of spatial autocorrelation. In addition, since spatial models of small sample geographic data are quite sensitive to a variety of model specification issues, tests for outlying and influential data points were applied (see [15]). In no case were outliers or highly leveraged cases found among the geographically aggregated units in either the youth or adult analyses.

One of the objectives for this study was to model the geographic relationships between drug use and drug sales. To do so, it was necessary to define a means of relating rates of illegal drug use and the measure of drug sales in nearby geographic units. This was accomplished using spatial lags, the measure of illegal drug sales in adjacent geographic units. The lags used in the current study were unique in character, taking into account not only the adjacency of spatial units one to the other, but also the density of interconnectedness of these units (called "Markov lags"). Based on graph theoretical representations of first order Markov processes, a spatial lag of order 1 is simply the average of the values of a variable across all units one unit distance from the target unit. A spatial lag of order 2 is the weighted average of the values of a variable across all units one and two units away from any target unit. Each first and second order unit is weighted by its density of interconnections, a well connected unit having greater weight than weakly connected unit. Adding these lagged effects into the analysis model, one can statistically test the independent contribution of three measures of drug sales upon use: a) the intrinsic relationship of illegal drug sales to use within each geographic unit; b) the first order lagged effect of drug sales to use between all target units and their immediate surroundings; and c) the second order lagged effect of drug sales to use between all target units and weighted second order surrounding units (some of which may be more well connected than others).

Because sample size varied greatly across the cells, the analyses presented here were corrected for heteroskedasticity by directly transforming the dependent and independent measures (multiplying each aggregated value by the square root of its sample size, see [16]). Community differences were controlled in the analysis first by regressing out community effects ($df = 20$) and then using the residuals from these regressions in the analyses. By doing this, we have effectively controlled for community differences. These individual community effects are not included in the tables to simplify presentation of the results.

RESULTS

Table 2 presents the results of the analyses for all youth 12 to 18 years old. Three models are shown, each successively stepping into the analyses: first, demographics, then the drinking measures, and then the measures of drug availability. For each model, the following information is shown: the *b*-values and associated *t*-values (in parentheses) for each independent variable, the measure of spatial autocorrelation (*z*-score in parentheses), and Rao's maximum likelihood estimate of the contribution of the independent measures to the explanation of variation in the dependent measure for the model.

As shown in Table 2, the demographic variables ($\Delta G^2 = 49.72$) and the drug availability ($\Delta G^2 = 24.90$) measures contributed significantly to the model examining the percentage of youths who were drug users, while the drinking variables did not contribute significantly to the model ($\Delta G^2 = 6.86$). Interpreting Model III in Table 2, the lagged effects of drug sales were substantive and important. Drug sales within any given area were unrelated to self-reported youth use. However, drug sales in areas adjacent to and surrounding any given area were related to self-reported youth use in the target area. It is noteworthy that few sociodemographic variables are significant in the final, most comprehensive model, Model III. Only percent male is significantly and negatively related to drug use among the sociodemographic variables.

Table 3 presents the results of the analyses of drug use among adults 19 years of age and older. Like the previous analysis for youth respondents, demographic variables ($\Delta G^2 = 67.44$) and the drug availability measures ($\Delta G^2 = 22.16$) significantly contribute to the explanation of the outcome, but the drinking measures are not ($\Delta G^2 = 9.07$). In this case however, local drug sales are negatively related to self-reported illegal drug use. Drug sales in areas immediately surrounding the local areas were significantly positively related to greater use in target areas. In these three models, significant negative spatial autocorrelation was observed. As with the youths, few sociodemographic variables are significant in the comprehensive model, only percent black.

DISCUSSION

As suggested in the introduction, the analyses presented in this article offer some descriptive information about the geographic relationships between drug use and availability. The results indicate that the use of illegal drugs was significantly positively related to sales of drugs in surrounding geographic areas for both youth and adults. This suggests that access to illegal drugs takes place across neighboring regions of urban communities in the United States. That is, residences of drug users are not in general coterminous with locations of drug supply. It can also be interpreted to suggest that increased access to illegal drugs (e.g., sales in surrounding areas) is related to greater use. This suggestion is,

Table 2. Regression Coefficients and (*t*-Values) for Spatial Analyses of Drug Use Among Youth (12 to 18)

Group	Variable name	Model I	Model II	Model III
Socio-demographics	Population density	.0291 (1.0480)	.0328 (1.1627)	.0184 (.6928)
	Percent young	-.9152 (-1.9865)*	-.5734 (-1.1241)	-.7612 (-1.5893)
	Percent low income	.0648 (.1706)	.1035 (.2693)	-.1064 (-.2945)
	Percent high income	.2023 (.3732)	.3591 (.6433)	-.1444 (-.2721)
	Percent unemployed	.1465 (.1439)	.5626 (.5495)	-.0544 (-.0561)
	Percent Hispanic	-.4649 (-.8779)	-.5820 (-1.1014)	-.8209 (-1.6353)
	Percent Black	-.4162 (-1.9865)*	-.4009 (-1.8025)*	-.2942 (-1.3826)
	Percent some college	.2435 (.7130)	.1686 (.4833)	.3507 (1.0710)
	Percent male	-.9397 (-2.0051)*	-.8971 (-1.7091)*	-1.0218 (-2.0741)*
Drinking	Percent drinkers		.2965 (.5301)	.5239 (.9692)
	Average frequency		.0094 (.1758)	.0146 (.2898)
	Average drinks per occasion		-.4131 (-1.9488)*	-.3901* (-1.9628)
	Average variance		.1472 (2.4936)**	.1560 (2.8095)***
Drug availability	Percent approached for sales			-.1593 (-.2219)
	Sales Lag 1			2.0729 (1.7447)*
	Sales Lag 2			3.3362 (2.5684)**
Spatial auto-correlation	ρ	-.1140 (-1.2393)	-.0996 (-1.0878)	-.1009 (-1.1553)
	ΔG^2	49.7156	6.8624	24.8976
	p	.0000***	.1433	.0000***

* $p < .05$, one-tailed
 ** $p < .01$, one-tailed
 *** $p < .005$, one-tailed

Table 3. Regression Coefficients and (*t*-Values) for Spatial Analyses of Drug Use Among Adults

Group	Variable name	Model I	Model II	Model III
Socio-demographics	Population density	-.0172 (-.5250)	.0016 (.0474)	-.0187 (-.5621)
	Percent young	-1.7883 (-1.8469)*	-1.0461 (-1.0368)	-1.1885 (-1.2435)
	Percent low income	-.3504 (-.5240)	.2900 (.4044)	.1789 (.2558)
	Percent high income	-.2919 (-.3731)	.2612 (.3207)	-.2239 (-.2842)
	Percent unemployed	.3884 (.2587)	.8951 (.5859)	.7116 (.4873)
	Percent Hispanic	1.4337 (1.7562)*	.4276 (.4758)	.4267 (.4988)
	Percent Black	-.6080 (-2.2214)*	-.8924 (-2.7690)***	-.7962 (-2.5631)**
	Percent some college	.1758 (.3063)	.2560 (.4135)	.6469 (1.0754)
	Percent male	-3.0921 (-2.6334)***	-1.5165 (-1.1335)	-.9571 (-.7502)
	Percent single	3.4850 (4.3656)***	3.3889 (4.0039)***	3.2736 (4.0049)***
Drinking	Percent drinkers		-.8340 (-1.1889)	-.9517 (-1.4211)
	Average frequency		.0089 (.2178)	-.0046 (-.1192)
	Average drinks per occasion		-.4119 (-1.1527)	-.3876 (-1.1292)
	Average variance		-.0495 (-.4265)	-.0260 (-.2348)
Drug availability	Percent approached for sales			-3.6408 (-3.0837)***
	Sales Lag 1			4.8285 (2.6711)***
	Sales Lag 2			.4563 (.2280)
Spatial auto-correlation	ρ	-.2114 (-2.3291)**	-.2426 (-2.6843)***	-.1626 (-1.7885)*
	ΔG^2	67.4392	9.0703	22.1647
	p	.0000***	.0594	.0001***

* $p < .05$, one-tailed** $p < .01$, one-tailed*** $p < .005$, one-tailed

however, contradicted by other results reported here. Increased access (reported sales among non-users) was inversely related to self-reported use within areas among adults. Thus, the areas in which greatest access areas (for adults) are not necessarily the areas of greatest use.

By examining the spatial component of drug availability and its relationship to self-reported use, we can begin to understand the nature of drug markets. This is especially important for designing preventive interventions that focus on reducing both the use and supply of drugs. In terms of community systems, these results suggest that at least some of the time the locations of illicit drug distribution systems are not the same as the consumption system. Thus, preventive interventions designed to reduce drug sales, drug use, and related problems may need to be located within different areas of communities. For instance, interventions designed to reduce drug sales should not necessarily be located in areas where the drug use is greatest, as this study suggests drug markets are more likely to be located in places immediately adjacent to high drug use areas. Similarly, these results also indicate that efforts to reduce illicit drug use should not be focused in community areas where drug sales are highest.

Of particular interest is the finding that youth drug use is related to drug availability in neighborhood areas that are adjacent to and two units from the areas in which youth reside. Because a higher proportion of youth than adults were current drug users and may be more likely to be targeted by drug sellers, the places where youth generally hang out and spend time, particularly those outside their neighborhood (e.g., malls, parks, athletic fields, and stadiums) may provide natural sites to target when developing interventions to reduce and eliminate drug markets. As suggested by the community systems framework these interventions can utilize both formal (e.g., police) and informal (e.g., shopkeepers at malls) control mechanisms to reduce drug availability.

Limitations

Because this is an aggregate-level analysis, we are unable to make statements about individual behavior. Thus, as noted above, we cannot say, based on our results, that the adults who used illicit drugs in one geographic unit were also approached more often for drug sales in adjacent geographic units. We can only say that geographic areas in which more adults used illicit drugs were adjacent to geographic areas in which adults were more often approached for drug sales. In the case of youths, this was true for geographic units that were separated by two zip codes as well as one zip code. Zip codes are administrative units and may not be the same as what residents view as their neighborhood. More information on the location of where respondents were when they were approached for drug sales would aid us in understanding the spatial dynamics between public drug markets and use. We may also have underestimated the availability of drugs by including only reports of drug sales by non-drug users. As current drug users may be more

likely to seek out or be known to drug sellers and therefore more likely to be approached for drug sales, the current measure provides a more accurate assessment of visible drug markets in neighborhood areas. Although the data were collected a decade ago, they have the advantage of providing a stratified random sample from a large number of American cities with oversampling of key minority groups, African-Americans and Hispanics; however, caution should be taken before generalizing these results with urban areas today.

The study was intended to ask whether spatial relationships among drug use and drug availability matter at all. While this study does not provide conclusive evidence regarding illegal drug availability and use, the statistically significant spatially lagged effects suggest previously unknown and unstudied spatial patterns and dynamics of both youth and adult illicit drug availability and drug use in community settings. Further research needs to explore the location and types of places where drug users purchase drugs versus the places where they are more likely to use drugs. Research should also continue to examine the differences between youth and adults on drug availability and use in order to develop more effective prevention strategies for different types of drug users.

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