Effects of Race, Neighborhood, and Social Network on Age at Initiation of Injection Drug Use

| Crystal M. Fuller, PhD, Luisa N. Borrell, DDS, PhD, Carl A. Latkin, PhD, Sandro Galea, MD, DrPH, Danielle C. Ompad, PhD, Steffanie A. Strathdee, PhD, and David Vlahov, PhD

Young or recent-onset injection drug users (IDUs) continue to be at high risk for acquiring hepatitis B and C virus infection as well as HIV.[1–9] Although drug dependence is classified as a psychiatric disorder, abundant evidence suggests that injection drug use is also a social problem, one that characterizes many disadvantaged settings both in the United States and abroad.[10–15] Therefore, it is conceivable that social processes are involved in the onset of injection, namely factors occurring at an individual level that may, in fact, be shaped by contextual-level factors (e.g., neighborhood characteristics). According to this premise, ignoring contextual or "neighborhood" factors can lead to an incomplete understanding of the relation between individual risk factors and disease. However, most studies of HIV risk behavior and onset of injection drug use have focused exclusively on individual-level risk factors.[13,16–19]

Research has shown that race/ethnicity plays an important role in initiation of illicit drug use, as well as risk for drug-related infectious disease such as HIV. Specifically, White drug users initiate illicit non-injection and injection drug use at a younger age than African Americans.[18,20–23] In addition, studies comparing individuals who do not use injection drugs and those who do have shown that White drug users are more likely to use injection drugs than African American drug users.[18,20] However, they are less likely to contract HIV.[24–28] This racial/ethnic difference in risk of HIV infection has not been fully explained.

Understanding the interrelationships between onset of injection drug use, race/ethnicity, and subsequent risk for HIV is critical to the implementation of targeted interventions designed to reduce not only risk of infectious disease but the onset of a lifelong injection habit. In addition, given the increased risk of infectious disease immediately

Objectives. We investigated individual- and neighborhood-level factors associated with adolescent initiation of injection drug use.

Methods. Injection drug users (IDUs) who had been injecting 2 to 5 years underwent HIV testing and completed a sociobehavioral risk survey. Modeling techniques accounting for intraneighborhood correlations were used in data analyses.

Results. Adolescent-initiating IDUs were less likely than adult-initiating IDUs to report high-risk sex and injection behaviors and more likely to report high-risk networks. African American IDUs from neighborhoods with large percentages of minority residents and low adult educational levels were more likely to initiate injection during adolescence than White IDUs from neighborhoods with low percentages of minority residents and high adult education levels.

Conclusions. Racial segregation and neighborhood-level educational attainment must be considered when drawing inferences about age at initiation of injection drug use and related high-risk behaviors. (*Am J Public Health.* 2005;95: 689–695. doi:10.2105/AJPH.2003.02178)

after the onset of injection drug use,[1,3,6–8,19] determining the ways in which onset of use and race/ethnicity affect early high-risk behaviors (i.e., those occurring immediately after initiation of injection drug use) is a viable next step.

The racial/ethnic differences that exist in illicit drug use and related infectious diseases may be due in part to social and contextual influences, which have received limited attention. Until recently, epidemiological research had not examined race as a social and contextual variable.[29] Residents of certain neighborhoods may find themselves at increased risk of initiating injection drug use as a result of the socioeconomic structure of their environment, independent of their individual race or socioeconomic status. For example, in impoverished neighborhoods drugs may be more available,[10] levels of psychological distress may be higher,[30] and there may be fewer alternative activities (e.g., employment opportunities).

On the basis of our earlier findings regarding neighborhood characteristics and distress,[31] we hypothesize that onset of injection drug use may be influenced by the racial composition, poverty level, or employment level of a given neighborhood. In addition,

given the body of research illustrating the relationship between high-risk networks and illicit drug use as well as HIV prevalence rates,[32–38] neighborhood characteristics may also affect individual-level risk behaviors (e.g., membership in high-risk networks) that follow the onset of injection drug use.

To expand on our previous work on racial/ethnic differences in onset of injection drug use,[18,21,39,40] we investigated the effects of race/ethnicity and high-risk behaviors on early initiation both before and after controlling for neighborhood-level characteristics. We also examined possible pathways through which neighborhood characteristics could interact with race to affect age at initiation. Such analyses may illuminate avenues for community-level prevention interventions among vulnerable populations facing potentially high burdens of drug dependence and blood-borne or sexually acquired infections.

METHODS

Study Population

Between July 1997 and May 1999, adolescent and young adult IDUs between the ages of 15 and 30 years were recruited into a pro-

spective study of HIV infection conducted in Baltimore (the Risk Evaluation and Assessment of Community Health [REACH II] Study). As described elsewhere,[21] a recreational vehicle (mobile clinic) and a clinic were employed as study venues. Briefly, outreach workers approached drug users in neighborhoods where drugs were bought or used (or both) and encouraged them to visit the stationary or mobile research site.

To be eligible for the study, individuals had to be between 15 and 30 years of age, had to have injected drugs for a period of 5 years or less before study entry, and had to report at least one injection in the 6 months before study entry. Participants' ages were verified through photo identifications that included their birth date (driver's license or state identification) or were accompanied by official documents containing their name and birth date (court, medical, or other social services paperwork). Injection status was verified through the presence of stigmata or "track marks" (scarring along the veins arms where injection occurs), commonly observed among IDUs. At each scheduled study visit, a modest remuneration was provided.

Data Collection

Eligible and consenting participants completed a structured interview conducted privately by trained staff. Along with pretest HIV counseling, venipunctures were conducted after the interview, and participants were offered referrals for medical and social services. After 2 weeks, at the HIV test result visit, participants were provided additional counseling and referrals. This study also included 6-month and 12-month follow-up visits in which participants completed interviewer-administered questionnaires and venipunctures; only baseline data were included in the present analyses.

Sociodemographic and serologic factors examined included age, gender, race/ethnicity, education level, juvenile arrest record, and HIV serostatus. We also assessed distance from the nearest needle exchange program (NEP) site in an attempt to determine the relationship between having an NEP close by and initiating injection drug use at a young age.

Variables related to early sex practices (including age at first sexual activity, trading sex for drugs, and condom use) and drug injection practices (e.g., sharing injection equipment, attending shooting galleries, injecting within a high-risk network, and having ever introduced someone to injection) were examined via reconstructions of participants' behavioral histories. These reconstructions entailed retrospective year-by-year assessments, spanning year of injection initiation to study entry, involving the use of a previously validated interviewer strategy (as described elsewhere[41,42]). They began with behaviors occurring in the most remote period and moved forward in time to the most recent period.

Data on age at initiation of injection drug use were collected, and initiation was the outcome variable in the present analyses. HIV antibodies were detected via enzyme-linked immunosorbent assays (Ortho Diagnostics, Raritan, NJ) and confirmed with Western Blot tests (Ortho Diagnostics).

Individual-Level Variables

In accordance with the guidelines of the American Academy of Pediatrics, a cutpoint for age at initiation of injection drug use of 21 years was used to distinguish adolescents from young adults. Racial/ethnic categories were defined as African American, White, and "other" (the latter accounting for less than 5% of the total study population). Education level was dichotomized as having dropped out or not dropped out of high school; dropouts were defined as those 18 years or older who reported that they had completed only "some" high school or those aged 15 to 17 years who reported that their highest grade completed was 8th grade or below (only 2 participants met the latter criterion). Distance from an NEP site was dichotomized as 1 mile (1.6 km) or more than 1 mile from such a site, and juvenile arrest was dichotomized as ever versus never.

Factors examined in association with early high-risk sex included trading of sex for drugs during the first year of initiating injection drug use (yes or no), condom use during the first year of initiation (not always vs always), and age at first sexual experience (13 years or younger vs more than 13 years). Early injection practices examined included sharing injection equipment during the first year of initiating injection drug use, attending a

shooting gallery to inject drugs, and injecting within a high-risk network. On the basis of previous research,[36,43] an injecting network was considered high risk if (1) an IDU injected with 1 or more other IDUs during the first injection year, (2) at least one of those individuals was not a personal acquaintance of the IDU, and (3) the number of injecting partners changed from year 1 to year 2 (suggesting an unstable network). Because of the inclusion of this social network variable, the study population was restricted to individuals who had injected for at least 2 years.

Neighborhood-Level Variables

Recruitment sites, selected as the neighborhoods where participants had grown up or currently resided, were geocoded to participants' census tracts. These sites were chosen as opposed to home addresses because approximately 30% of the study population reported being homeless or not having an address. Among those who were able to provide a home address, 85% lived in the neighborhood where they were recruited.

Using Summary Tape File 3A from the 1990 US Census,[44] we obtained data on census tract variables representing education, employment, percentage of minority residents, and poverty level. Neighborhood education level was dichotomized as neighborhoods in which 45% or fewer of adult residents had or did not have at least a high school or general equivalency diploma (based on the 75th percentile of the distribution of the overall population). Neighborhood employment level, defined as the percentage of people 16 years or older reporting being employed, was specified as a continuous variable. Neighborhood racial/ethnic composition was dichotomized as neighborhoods in which 75% or more of residents identified or did not identify themselves with a minority racial/ethnic group (based on the mean distribution of the overall population). Nearly all (99%) of the minority residents in these census tracts were African American. Neighborhood poverty rate was defined as the percentage of neighborhood residents living below the poverty level[45]; this variable was dichotomized as 40% or more versus less than 40% of the population being classified as below the poverty level (based on the median of the distribution of the overall population).

Data Analysis

To compare sociodemographic factors, HIV seropositivity rates, and early high-risk behaviors (i.e., behaviors occurring within the first year or 2 years of injection initiation) associated with adolescent initiation of injection drug use, we calculated frequencies, means, or medians for each variable of interest as appropriate. As a means of assessing interactions, distributions of individual and neighborhood characteristics were examined for each racial group according to age of initiation. Depending on the variable in question, we determined statistically significant differences using either t tests or χ^2 analyses.

To assess the magnitude of the association between race and age at initiation, we fit several models using backward elimination. First, we fit logistic regression models to estimate the crude association between age at initiation and each individual and neighborhood covariate. Second, we fit a logistic regression model to estimate the association between age at initiation and race after adjusting for all individual covariates. Covariates selected for model building were based on P values below .10. Third, after eliminating nonsignificant covariates, we included the neighborhood covariates in the model.

Plausible 2-way and 3-way interaction terms were examined through stratification, tested, and entered one at a time in the main effects model. We conducted analyses using SUDAAN (Research Triangle Institute, Research Triangle Park, NC) to account for intraneighborhood outcome correlations.[46] Findings were almost identical when the SAS GENMOD procedure was used, and thus we present results obtained with SUDAAN.

RESULTS

Of the 276 IDUs screened, 226 (82%) were eligible for REACH II according to the study criteria, and 144 were included in the present analyses (in which the population was restricted to IDUs who had been injecting for 2–5 years); 51% of these individuals had initiated injection drug use during adolescence. More than half of the study population was African American (63%) and female (60%). The median age was 25 years (range: 15–30 years), and the median age at initiation of in-

TABLE 1—Sociodemographic and Serologic Characteristics Associated With Adolescent Initiation Among Recent-Onset Injection Drug Users (n = 144)

	No. (%)	Initiation Age ≤ 21 y, No. (%)	Odds Ratio (95% Confidence Interval)
Race			
African American	91 (63)	34 (37)	0.21* (0.21, 0.45)
White	53 (37)	39 (74)	1
Gender			
Female	86 (60)	39 (45)	0.59 (0.30, 1.05)
Male	58 (40)	34 (59)	1
Education level			
Less than high school	86 (60)	47 (55)	1.58 (0.80, 3.09)
High school or more	58 (40)	26 (45)	1
Juvenile arrest			
Yes	27 (19)	19 (70)	2.77* (1.12, 6.83)
No	117 (81)	46 (54)	1
Distance from needle exchange program			
≤ 1 mi	75 (52)	34 (45)	0.65 (0.44, 1.98)
> 1 mi	68 (48)	38 (56)	1
HIV serostatus			
Positive	10 (15)	7 (47)	0.84 (0.29, 2.44)
Negative	129 (90)	66 (51)	1

Note. The median age of the sample was 25 years (range: 15–30), and the median age at initiation was 21 years (range: 10–28).
*$P \leq .01$.

jection was 21 years (range: 10–28 years) (Table 1). Those who had initiated injection during adolescence were less likely than young adult initiates to be African American (odds ratio [OR]=0.21) and more likely to have been arrested as a juvenile (OR=2.77). There were no differences between adolescent and young adult initiators with respect to gender, HIV seroprevalence, or distance from an NEP.

Table 2 shows that adolescent initiators were twice as likely as young adults to report their first sexual experience as having taken place before they were 14 years of age (OR=2.23). Frequencies of trading sex for drugs and using condoms during the first year after injection did not significantly differ according to age at initiation. In terms of early injection practices, adolescent initiators were significantly less likely than young adult initiators to share injection equipment during their first year of injection drug use (OR=0.48). Having a high-risk network, attending a shooting gallery during the first year of use, and subsequently introducing someone else

to injection drug use did not differ significantly according to age at initiation.

In Table 3, we present the sociodemographic characteristics of the neighborhoods of new IDUs associated that were associated with adolescent versus young adult initiation. In general, neighborhoods of new IDUs tended to have fewer people 16 years or older reporting employment, higher percentages of minority residents, and lower education levels. Also, in comparison with young adult initiators, adolescent initiators tended to reside in neighborhoods with lower percentages of people living below the poverty level. However, none of these associations achieved statistical significance with regard to age at initiation.

Table 4 presents results from the final models in which (1) only individual-level effects were considered, and (2) both individual- and neighborhood-level effects were considered. The independent effect of having a high-risk social network was substantially reduced by 20% when the 2 models were compared, while the remaining independent effects of ju-

TABLE 2—High-Risk Sexual and Injection Behaviors Associated With Adolescent Initiation Among Recent-Onset Injection Drug Users (n = 144)

	No. (%)	Initiation Age ≤ 21 y, No. (%)	Odds Ratio (95% Confidence Interval)
Age at first sexual activity, y			
≤ 13	65 (45)	40 (62)	2.23* (1.14, 4.36)
> 13	79 (55)	33 (42)	1
Traded sex for drugs in year after initiation			
Yes	43 (30)	17 (40)	0.53 (0.25, 1.09)
No	101 (55)	56 (55)	1
Condom use in year after initiation			
Always	47 (33)	49 (57)	1.94* (0.95, 3.95)
Not always	58 (40)	24 (41)	1
Shared injection equipment in year after initiation			
Yes	91 (63)	40 (44)	0.48* (0.24, 0.95)
No	53 (37)	33 (62)	1
Shooting gallery use in year after initiation			
Yes	51 (35)	25 (49)	0.75 (0.37, 1.50)
No	93 (65)	48 (52)	1
High-risk network in 2-year period after initiation[a]			
Yes	7 (5)	6 (86)	6.27* (0.74, 53.41)
No	137 (95)	67 (49)	1
Introduced someone to injection drug use			
Yes	23 (16)	12 (52)	1.07 (0.44, 2.62)
No	121 (84)	61 (50)	1

[a]Defined as those reporting that they injected with more than 1 injecting partners in year 1, that at least one injecting partner was a stranger, and that the number of injecting partners changed from year 1 to year 2.
*$P \leq .01$.

TABLE 3—Sociodemographic Characteristics of Neighborhoods Associated With Age at Initiation of Injection Drug Use (n = 144)

	No. (%)	Initiation Age ≤ 21 y, No. (%)	Odds Ratio (95% Confidence Interval)
Rate of adult employment, %[a]	143 (35.5)	72 (36.3)	1.58 (0.10, 25.97)
Minority composition, %			
≥ 75	96 (66.7)	46 (63.0)	0.72 (0.45, 1.15)
< 75	48 (33.3)	27 (37.0)	1
High school education, %			
≥ 45	32 (22.2)	14 (19.2)	0.7 (0.34, 1.46)
< 45	112 (77.8)	59 (80.8)	1
Living below poverty level, %			
≥ 40	70 (48.6)	33 (45.2)	0.76 (0.48, 1.21)
< 40	74 (51.4)	40 (54.8)	1

Note. Each neighborhood social characteristic is presented as the percentage of individuals in the zip code area from which a particular individual was recruited.
[a]Treated as a continuous variable.

venile arrest, early syringe sharing, and condom use remained unchanged. The model including both individual and neighborhood characteristics also showed that the individual race effect was significantly modified by 2 neighborhood characteristics, education and minority composition: African Americans who lived in neighborhoods with high percentages of minority residents, but in which 45% or less of the adult population had a high school education, were nearly 4 times more likely to initiate use during adolescence than their White counterparts living in neighborhoods with lower minority percentages and with more than 45% of the adult population having a high school diploma.

DISCUSSION

The major finding of this study was that features of the social environment, specifically neighborhood minority composition and education, are important in explaining the association between age at initiation of injection drug use and race/ethnicity. Specifically, relative to White injection drug users from neighborhoods with lower percentages of minority residents and higher educational levels, African Americans from neighborhoods with high percentages of minority residents and low educational levels were more likely to initiate use during adolescence. In neighborhoods in which percentages of minority residents and educational levels were high, there was no significant difference in regard to race/ethnicity and adolescent initiation. These results suggest that, rather than race alone, the interaction of neighborhood characteristics and race determines age at initiation of injection drug use.

Previous reports examining individual-level effects have consistently shown that White non-injection and injection drug users are younger at initiation of use than their African American counterparts.[18,20–23] Although published reports of neighborhood effects on initiation of drug use have been sparse,[10,47] evidence from other studies of neighborhood effects on health outcomes suggests mechanisms through which neighborhood racial/ethnic composition and educational level may affect adolescent risk behaviors. Segregated neighborhoods in which aggregate educational levels are low have been considered to wield a "concentration effect."[48] That is, residents of these segregated areas face a double burden: they have to grapple with problems rooted in lack of income or employment while dealing with the social consequences of living in a place where most people are poor. Similarly, sev-

TABLE 4—Individual-Level and Hierarchical Logistic Regression Models of High-Risk Behaviors and Neighborhood Effects Associated With Adolescent Initiation of Injection Drug Use (n = 144)

Characteristic	Individual Effects,[a] Adjusted OR (95% CI)	Individual and Neighborhood Effects,[b] Adjusted OR (95% CI)
AA vs White	0.18 (0.08, 0.40)	0.07 (0.05, 0.11)
Juvenile arrest: yes vs no	3.65 (1.31, 10.20)	3.72 (1.65, 8.40)
Shared vs did not share injection equipment in year after initiation	0.38 (0.16, 0.82)	0.38 (0.16, 0.91)
High-risk network during 2 years after initiation: yes vs no	17.52 (1.89, 162.47)	14.06 (5.98, 33.02)
Condom use in year after initiation: always vs not always	2.03 (0.89, 4.64)	2.08 (1.09, 3.99)
Minority composition: ≥ 75% vs < 75%	. . .	0.87 (0.48, 1.60)
Completed HS: ≤ 45% vs > 45%	. . .	1.67 (0.10, 26.62)
3-way interaction term[c]		
AA × ≥ 75% Minority × ≤ 45% HS Diploma	. . .	3.66 (2.11, 6.34)
AA × ≥ 75% Minority × > 45% HS Diploma	. . .	1.56 (0.08, 31.30)
White × < 75% Minority × > 45% HS Diploma (reference)	. . .	. . .

Note. AA = African American; HS = high school.
[a]Adjusted for individual-level effects only, via multiple logistic regression.
[b]Adjusted for both individual- and neighborhood-level effects via SUDAAN modeling techniques.
[c]All other joint effects of this interaction term demonstrated no associations.

eral studies have confirmed an association between residential location and physical health and mortality, independent of individual socioeconomic status.[49,50]

The consequences of poor neighborhood living conditions can be far-reaching, and their relationship with individual risk behaviors can operate through a number of mechanisms. For example, social disorganization theory has been used to conceptualize the reciprocal influence of neighborhoods on social behaviors. This theory rests on the importance of community in regard to maintaining effective social controls.[51] Lack of sufficient social controls may lead to or exacerbate crime, violence, and drug use.[52] Residing in neighborhoods characterized by social and material deprivation may lead to social disorganization, thereby influencing age at initiation of injection drug use, particularly among African Americans.

A second plausible mechanism through which neighborhood characteristics can influence individual behavior is low social capital or high income inequality, which can be characterized by smaller proportions of budgets being spent on education.[53–55] Such social disinvestment translates into poorer educational outcomes,[54] as evidenced by higher rates of unemployment, incarceration, and income assistance. In turn, these factors have been associated with community prevalence rates of injection drug use.[10] Moreover, residing in highly impoverished urban environments may influence drug initiation in that individuals are exposed to stressful situations, distress, and feelings of hopelessness.[56]

It is noteworthy that, in race-specific analyses (data not shown), we found that the mean educational levels of neighborhoods where individuals initiated drug use at a young age were similar. However, White adolescent-initiating drug users were predominantly recruited from neighborhoods with higher employment levels, higher median household incomes, and low levels of poverty, suggesting that the same educational attainment levels may not necessarily translate into similar neighborhood conditions for African Americans and Whites. This finding is consistent with a previous analysis of the 171 largest cities in the United States indicating that the worst contexts in which Whites reside were considerably better than the average contexts in which African Americans reside.[57]

After adjustment for neighborhood-level variables, some of the individual-level charac-teristics remained independently associated with adolescent initiation of injection drug use. Specifically, while adolescent initiators reported safer sex and injection practices, they were more likely to report high-risk networks after initiation. Several studies conducted among IDUs have identified similar injection network characteristics as leading to a high risk of HIV infection.[43,58–60] Our findings suggest that adolescent initiators (during the present study's time frame), unlike young adult initiators, may not have begun sharing syringes until the second or third year after initiation; such early changes in risk network structure and composition may also differ according to race.[25] Thus, future research examining how IDUs' networks change over a high-risk period such as the first few years of injection drug use,[7,61] as well as comparing network changes among IDUs and non-IDU comparison groups, would further elucidate these findings.

Neighborhood characteristics may also have an influence on the particular effects of one's social network, as evidenced by the 20% reduction observed in our social network estimate when neighborhood racial composition and education were taken into account. Hence, our findings provide support for structural HIV prevention intervention strategies targeting environments in which there are high-risk social networks. However, despite the strong independent association observed between social networks and age at initiation, our estimate may be somewhat unstable owing to the small number of individuals who reported injecting in high-risk settings at the onset of injection drug use (i.e., injecting with multiple partners they might not have personally known). Thus, larger studies examining race and social networks among drug users from more heterogeneous neighborhoods are warranted to determine whether features of certain communities operate the same in different socioeconomic circumstances.

It is important to note a few drawbacks of this study. First, it is evident that the use of census tracts as crude proxies for neighborhoods may be problematic, in that census tracts may not be coterminous with neighborhood boundaries. Although there is little agreement regarding the optimal geographic

area to use in studies such as this one, recent research indicates that the smaller the geographic area (e.g., block groups), the smaller the magnitude of bias due to aggregate proxy data. However, studies have also shown only minimal differences between estimates derived from census tracts and block groups.[62–65] Thus, our results indicate that neighborhood characteristics probably explain interindividual variabilities in injection initiation and subsequent risk behaviors not explained by individual-level factors. If bias occurs as a result of using a larger (as opposed to smaller) geographic area in defining neighborhoods, our results probably represent underestimates of the true effects.

Second, our small sample size and the homogeneity of neighborhood conditions from which our participants were drawn must also be acknowledged. The small sample size hindered our ability to test multiple interactions, and the lack of variation in characteristics between neighborhoods may have limited our ability to detect significant contextual effects. In this context, however, our findings probably represent underestimations of the contribution of neighborhood conditions to age at initiation of injection drug use.

Third, exposure levels may have been classified incorrectly as a result of biased recall or difficulty recalling behavioral events. To minimize recall bias, we referred to other memorable biographical landmarks (i.e., pregnancy, childbirth, time spent incarcerated, last school grade attended) that could assist participants in recalling the chronological sequence of their high-risk behaviors. Also, our sample was restricted to those with relatively short injection histories, unlike previous studies in which such year-by-year behavioral reconstructions have been validated.[41] In spite of the measures just described, nondifferential misclassification could have occurred, which would tend to bias the associations observed toward the null.[42]

Finally, our lack of data on long-term residential histories—an issue that has been the focus of debate in regard to research on neighborhood effects—could have been problematic. However, data from the 1990 US census showed that 60% of Maryland residents had lived in the same house for the past 5 years.[44] Moreover, existing evidence

suggests that when people relocate, most tend to move to neighborhoods similar to their former ones.[50,63,65] Therefore, we believe that the contextual effects observed here are likely to be meaningful and real.

Our results suggest that neighborhood characteristics contributed to the racial/ethnic differences we observed. Although the degree to which our findings are generalizable to drug-using populations in other settings is uncertain (indicating the need for additional studies), they do, in fact, have implications for both public health research and practice. For example, research aimed at understanding the determinants of injection risk behavior should focus on both individual- and neighborhood-level factors, as well as their interaction. From a public health intervention perspective, it is essential to understand that neighborhood factors may have independent effects on individual risks. Thus, interventions targeting only individuals are bound to fall short, and public health efforts involving multiple levels of action may be more efficient and produce sustainable benefits. ■

About the Authors

Crystal M. Fuller and Luisa N. Borrell are with the Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY. Crystal M. Fuller is also with the Center for Urban Epidemiologic Studies, New York Academy of Medicine, New York. Carl A. Latkin is with the Department of Health Policy and Management, Johns Hopkins Bloomberg School of Public Health, Baltimore, Md. Sandro Galea and Danielle C. Ompad are with the Center for Urban Epidemiologic Studies, New York Academy of Medicine. Steffanie A. Strathdee and David Vlahov are with the Infectious Disease Program, Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health. David Vlahov is also with the Center for Urban Epidemiologic Studies, New York Academy of Medicine, and the Department of Epidemiology, Mailman School of Public Health.

Requests for reprints should be sent to Crystal M. Fuller, PhD, Center for Infectious Disease Epidemiologic Research, Department of Epidemiology, Mailman School of Public Health, Columbia University, 722 W 168th St, 4th Floor, Room R422, New York, NY 10032 (e-mail: cf317@columbia.edu).

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Contributors

C.M. Fuller directed all data collection efforts, contributed to the study concept and design, and conducted the majority of the analyses. L. N. Borrell led the conduct and interpretation of the hierarchical analysis component and contributed to the writing and overall development of the article. C. A. Latkin contributed to the writing and overall development of the article. S. Galea contributed to interpretation of findings and

to the development and writing of the article. D.C. Ompad coordinated the data collection efforts and contributed to data management, cleaning, and editing. S.A. Strathdee contributed to the development and writing of the article. D. Vlahov oversaw all data collection and data-analytic efforts and contributed to the development and writing of the article.

Human Participant Protection

This study was approved by the institutional review board of the Johns Hopkins Bloomberg School of Public Health. Participants provided written informed consent.

References

1. Vlahov D, Anthony JC, Celentano D, Solomon L, Chowdhury N. Trends of HIV-1 risk reduction among initiates into intravenous drug use, 1982–1987. *Am J Drug Alcohol Abuse.* 1991;17:39–48.

2. Nicolosi A, Leite ML, Musicco M, Molinari S, Lazzarin A. Parenteral and sexual transmission of human immunodeficiency virus in intravenous drug users: a study of seroconversion. The Northern Italian Seronegative Drug Addicts (NISDA) Study. *Am J Epidemiol.* 1992;135:225–233.

3. van Ameijden EJ, Van den Hoek JA, Mientjes GH, Coutinho RA. A longitudinal study on the incidence and transmission patterns of HIV, HBV and HCV infection among drug users in Amsterdam. *Eur J Epidemiol.* 1993;9:255–262.

4. Nelson KE, Vlahov D, Solomon L, Cohn S, Munoz A. Temporal trends of incident human immunodeficiency virus infection in a cohort of injecting drug users in Baltimore, Md. *Arch Intern Med.* 1995;155:1305–1311.

5. Fennema JS, van Ameijden EJ, Van Den HA, Coutinho RA. Young and recent-onset injecting drug users are at higher risk for HIV. *Addiction.* 1997;92:1457–1465.

6. Garfein RS, Vlahov D, Galai N, Doherty MC, Nelson KE. Viral infections in short-term injection drug users: the prevalence of the hepatitis C, hepatitis B, human immunodeficiency, and human T-lymphotropic viruses. *Am J Public Health.* 1996;86:655–661.

7. Garfein RS, Doherty MC, Monterroso ER, Thomas DL, Nelson KE, Vlahov D. Prevalence and incidence of hepatitis C virus infection among young adult injection drug users. *J Acquir Immune Defic Syndr Hum Retrovirol.* 1998;18(suppl 1):S11–S19.

8. Thorpe LE, Ouellet LJ, Levy JR, Williams IT, Monterroso ER. Hepatitis C virus infection: prevalence, risk factors, and prevention opportunities among young injection drug users in Chicago, 1997–1999. *J Infect Dis.* 2000;182:1588–1594.

9. Hahn JA, Page-Shafer K, Lum PJ, Ochoa K, Moss AR. Hepatitis C virus infection and needle exchange use among young injection drug users in San Francisco. *Hepatology.* 2001;34:180–187.

10. Boardman JD, Finch BK, Ellison CG, Williams DR, Jackson JS. Neighborhood disadvantage, stress, and drug use among adults. *J Health Soc Behav.* 2001;42:151–165.

11. Musto DF. *The American Disease: Origins of Narcotic Control.* New York, NY: Oxford University Press Inc; 1999.

12. Gracey M. Child health implications of worldwide urbanization. *Rev Environ Health.* 2003;18:51–63.

13. Roy E, Haley N, Leclerc P, Cedras L, Blais L, Boivin JF. Drug injection among street youths in Montreal: predictors of initiation. *J Urban Health.* 2003;80:92–105.

14. Galea S, Vlahov D. Social determinants and the health of drug users: socioeconomic status, homelessness, and incarceration. *Public Health Rep.* 2002; 117(suppl 1):S135–S145.

15. Levine SB, Coupey SM. Adolescent substance use, sexual behavior, and metropolitan status: is "urban" a risk factor? *J Adolesc Health.* 2003;32:350–355.

16. Dinwiddie SH. Characteristics of injection drug users derived from a large family study of alcoholism. *Compr Psychiatry.* 1997;38:218–229.

17. Des J, Friedman SR, Perlis T, et al. Risk behavior and HIV infection among new drug injectors in the era of AIDS in New York City. *J Acquir Immune Defic Syndr Hum Retrovirol.* 1999;20:67–72.

18. Fuller CM, Vlahov D, Ompad DC, Shah N, Arria A, Strathdee SA. High-risk behaviors associated with transition from illicit non-injection to injection drug use among adolescent and young adult drug users: a case-control study. *Drug Alcohol Depend.* 2002;66:189–198.

19. van Ameijden EJ, Van den Hoek JA, Hartgers C, Coutinho RA. Risk factors for the transition from non-injection to injection drug use and accompanying AIDS risk behavior in a cohort of drug users. *Am J Epidemiol.* 1994;139:1153–1163.

20. Golub A, Johnson BD. Variation in youthful risks of progression from alcohol and tobacco to marijuana and to hard drugs across generations. *Am J Public Health.* 2001;91:225–232.

21. Fuller CM, Vlahov D, Arria AM, Ompad DC, Garfein R, Strathdee SA. Factors associated with adolescent initiation of injection drug use. *Public Health Rep.* 2001;116(suppl 1):136–145.

22. Kral AH, Lorvick J, Edlin BR. Sex- and drug-related risk among populations of younger and older injection drug users in adjacent neighborhoods in San Francisco. *J Acquir Immune Defic Syndr.* 2000;24: 162–167.

23. Ellickson PL, Morton SC. Identifying adolescents at risk for hard drug use: racial/ethnic variations. *J Adolesc Health.* 1999;25:382–395.

24. Kral AH, Bluthenthal RN, Booth RE, Watters JK. HIV seroprevalence among street-recruited injection drug and crack cocaine users in 16 US municipalities. *Am J Public Health.* 1998;88:108–113.

25. Kottiri BJ, Friedman SR, Neaigus A, Curtis R, Des J. Risk networks and racial/ethnic differences in the prevalence of HIV infection among injection drug users. *J Acquir Immune Defic Syndr.* 2002;30:95–104.

26. Chaisson RE, Moss AR, Onishi R, Osmond D, Carlson JR. Human immunodeficiency virus infection in heterosexual intravenous drug users in San Francisco. *Am J Public Health.* 1987;77:169–172.

27. Schoenbaum EE, Hartel D, Selwyn PA, et al. Risk factors for human immunodeficiency virus infection in intravenous drug users. *N Engl J Med.* 1989;321:874–879.

28. Watters JK, Estilo MJ, Kral AH, Lorvick JJ. HIV infection among female injection-drug users recruited in community settings. *Sex Transm Dis.* 1994;21:321–328.

29. Jones CP. Invited commentary: "race," racism, and the practice of epidemiology. *Am J Epidemiol.* 2001; 154:299–304.

30. Ganz ML. The relationship between external threats and smoking in central Harlem. *Am J Public Health.* 2000;90:367–371.

31. Latkin CA, Forman V, Knowlton A, Sherman S. Norms, social networks, and HIV-related risk behaviors among urban disadvantaged drug users. *Soc Sci Med.* 2003;56:465–476.

32. Magura S, Grossman JI, Lipton DS, et al. Determinants of needle sharing among intravenous drug users. *Am J Public Health.* 1989;79:459–462.

33. Page BJ. Shooting scenarios and risk of HIV-1 infection. *Am Behav Sci.* 1990;33:478–490.

34. Neaigus A, Friedman SR, Jose B, et al. High-risk personal networks and syringe sharing as risk factors for HIV infection among new drug injectors. *J Acquir Immune Defic Syndr Hum Retrovirol.* 1996;11:499–509.

35. Latkin C, Mandell W, Oziemkowska M, et al. Using social network analysis to study patterns of drug use among urban drug users at high risk for HIV/AIDS. *Drug Alcohol Depend.* 1995;38:1–9.

36. Valente TW, Vlahov D. Selective risk taking among needle exchange participants: implications for supplemental interventions. *Am J Public Health.* 2001;91:406–411.

37. Downs WR, Rose SR. The relationship of adolescent peer groups to the incidence of psychosocial problems. *Adolescence.* 1991;26:473–492.

38. Newcomb MD, Maddahian E, Bentler PM. Risk factors for drug use among adolescents: concurrent and longitudinal analyses. *Am J Public Health.* 1986;76:525–531.

39. Carneiro M, Fuller C, Doherty MC, Vlahov D. HIV prevalence and risk behaviors among new initiates into injection drug use over the age of 40 years old. *Drug Alcohol Depend.* 1999;54:83–86.

40. Fuller CM, Vlahov D, Latkin CA, Ompad DC, Celentano DD, Strathdee SA. Social circumstances of initiation of injection drug use and early shooting gallery attendance: implications for HIV intervention among adolescent and young adult injection drug users. *J Acquir Immune Defic Syndr.* 2003;32:86–93.

41. Anthony JC, Vlahov D, Celentano D, et al. Self-report interview data for a study of HIV-1 infection among intravenous drug users: description of methods and preliminary evidence on validity. *J Drug Issues.* 1991;21:739–757.

42. Samuels JF, Vlahov D, Anthony JC, Chaisson RE. Measurement of HIV risk behaviors among intravenous drug users. *Br J Addict.* 1992;87:417–428.

43. Latkin C, Mandell W, Vlahov D, Oziemkowska M, Celentano D. People and places: behavioral settings and personal network characteristics as correlates of needle sharing. *J Acquir Immune Defic Syndr Hum Retrovirol.* 1996;13:273–280.

44. *Summary Tape File 3 CD-ROM Technical Documentation.* Washington, DC: US Bureau of the Census; 1992.

45. *Current Population Survey (CPS)—Definitions and Explanations.* Washington, DC: US Bureau of the Census; 2002.

46. Brogan D. *Encyclopedia of Biostatistics, Volume 5: Software for Sample Survey Data, Misuse of Standard Packages.* New York, NY: John Wiley & Sons Inc; 1998: 4167–4174.

47. Lillie-Blanton M, Anthony JC, Schuster CR. Probing the meaning of racial/ethnic group comparisons in crack cocaine smoking. *JAMA.* 1993;269:993–997.

48. Wilson WJ. *The Truly Disadvantaged.* Chicago, Ill: University of Chicago Press; 1987.

49. Duncan C, Jones K, Moon G. Psychiatric morbidity: a multilevel approach to regional variations in the UK. *J Epidemiol Community Health.* 1995;49:290–295.

50. Haan M, Kaplan GA, Camacho T. Poverty and health: prospective evidence from the Alameda County Study. *Am J Epidemiol.* 1987;125:989–998.

51. Sampson RJ, Groves WR. Community structure and crime: testing social-disorganization theory. *Am J Sociol.* 1989;94:774–802.

52. Shaw C, McKay H. *Juvenile Delinquency in Urban Areas.* Chicago, Ill: University of Chicago Press; 1942.

53. Lynch J. Income inequality and health: expanding the debate. *Soc Sci Med.* 2000;51:1001–1005.

54. Kaplan GA, Pamuk ER, Lynch JW, Cohen RD, Balfour JL. Inequality in income and mortality in the United States: analysis of mortality and potential pathways. *BMJ.* 1996;312:999–1003.

55. Kawachi I, Berkman L. Social cohesion, social capital and health. In: Berkman L, Kawachi I, eds. *Social Epidemiology.* New York, NY: Oxford University Press Inc; 2000:174–190.

56. Latkin CA, Curry AD. Stressful neighborhoods and depression: a prospective study of the impact of neighborhood disorder. *J Health Soc Behav.* 2003;44:34–44.

57. Sampson RJ, Wilson WJ. Toward a theory of race, crime and urban inequality. In: Hagan J, Petersen RD, eds. *Crime and Inequality.* Stanford, Calif: Stanford University Press; 1995:37–54.

58. Latkin C, Mandell W, Vlahov D, Knowlton A, Oziemkowska M, Celentano D. Using social network analysis to study patterns of needle sharing and shooting gallery attendance. *Soc Networks.* 1995;17:219–228.

59. Rothenberg RB, Potterat JJ, Woodhouse DE, Muth SQ, Darrow WW, Klovdahl AS. Social network dynamics and HIV transmission. *AIDS.* 1998;12:1529–1536.

60. Friedman SR, Neaigus A, Jose B, et al. Sociometric risk networks and risk for HIV infection. *Am J Public Health.* 1997;87:1289–1296.

61. Obadia Y, Feroni I, Perrin V, Vlahov D, Moatti JP. Syringe vending machines for injection drug users: an experiment in Marseille, France. *Am J Public Health.* 1999;89:1852–1854.

62. Geronimus AT, Bound J. Use of census-based aggregate variables to proxy for socioeconomic group: evidence from national samples. *Am J Epidemiol.* 1998; 148:475–486.

63. Diez Roux AV, Merkin SS, Arnett D, et al. Neighborhood of residence and incidence of coronary heart disease. *N Engl J Med.* 2001;345:99–106.

64. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology. *Am J Public Health.* 1992;82:703–710.

65. Diez-Roux AV, Kiefe CI, Jacobs DR Jr, et al. Area characteristics and individual-level socioeconomic position indicators in three population-based epidemiologic studies. *Ann Epidemiol.* 2001;11:395–405.