Measurement of HIV risk behaviors among intravenous drug users

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Abstract
This paper reviews issues related to the measurement of drug use and other behaviors in studies of human immunodeficiency virus (HIV) infection in intravenous drug users. These issues include: (1) choice of variables, (2) study design, (3) time frame of measurement, (4) categories of measurement, (5) interviewer effects, and (6) validity of measurement. Difficulties and approaches for measuring drug use and other intimate behaviors in intravenous drug users are discussed. Attempts to come to terms with these measurement issues in the context of HIV infection in intravenous drug users should lead to the further development of methods for use in the general context of drug abuse research.

Introduction
Intravenous drug users are at high risk for infection with the human immunodeficiency virus (HIV), the primary etiologic agent of the acquired immunodeficiency syndrome (AIDS). Ongoing studies are seeking to identify specific modes of HIV transmission and risk factors for progression to AIDS in intravenous drug-taking populations. As reviewed extensively elsewhere, the primary mode of HIV transmission between intravenous drug users is parenteral, through the sharing of contaminated needles and syringes (Friedland & Klein, 1987; Des Jarlais et al., 1988). Given the current limitations of chemotherapy for HIV, these studies have provided critical information for designing behavioral interventions to prevent further transmission of infection. Both the early observational studies and newer trials to test the effectiveness of behavioral interventions have a heavy dependence upon careful measurement of the behaviors associated with IV drug use (Brickner et al., 1989; Donoghoe et al., 1989). The purpose of this paper is to review issues related to measurement of these behaviors among intravenous drug users. Relevant issues include: (1) choice of variables, (2) study design, (3) time frame of measurement, (4) categories of measurement, (5) interviewer effects, and (6) validity of measurement. Attempts to deal with these issues in the context of HIV infection should contribute to the measurement of intravenous drug use and other intimate behaviors in a variety of investigations.

Choice of variables
For maximum utility, research on risk behaviors for HIV infection in intravenous drug users is guided by a theoretical framework specifying hypothesized causal pathways, mediating variables, moderating influences, and potentially confounding factors (Kaplan, 1989). In the absence of formal theory, the early stages of research on HIV infection in intravenous drug users can be guided by systematic
judgments about biologically plausible risk characteristics, by empirical findings about the transmission of blood-borne agents by parenteral and sexual routes, and by ethnographic observations of intravenous drug users.

As evidence for the viral etiology of AIDS accumulated, investigators focused attention on behaviors that might facilitate transmission of blood-borne organisms (Edelman, 1984). Variables that have been considered in epidemiologic studies of intravenous drug users include the frequency of drug injection and the proportion of injection with 'booting', that is, the repeated withdrawal and reinjection of blood by the user. The practice of 'booting' is reported by many drug users to prolong or enhance drug effects. 'Booting' also increases the volume of residual blood in a syringe, and presumably the dose of an infectious agent. Other variables of interest involve sharing injection equipment, such as the proportion of injections that involve shared, and therefore potentially contaminated, needles and syringes; the number of different drug users with whom needles and syringes are shared; and the sharing of 'cookers'. 'Cookers' are small vessels, such as bottle caps, used to heat and dissolve drugs prior to injection. Epidemiologic studies have also measured the proportion of injections in 'shooting galleries', clandestine locations where drug users can borrow or rent injection equipment. The repeated use of needles and syringes in this setting amounts to a pattern of sequential, anonymous sharing of potentially contaminated injection equipment. The rinsing of needle and syringe with water or disinfectant before injection, which is intended to flush out blood residue from a previous user, also has been considered.

Several early reports noted an association between antibody to HIV and frequency of injection, proportion of injections in 'shooting galleries', and number of different needle-sharing partners (Friedland et al., 1985; Chaissong et al., 1987; Marmor et al., 1987; Schoenbaum et al., 1989). This evidence was consistent with the idea of parenteral transmission of HIV. However, several practices hypothesized to increase the risk of infection, such as 'booting' or sharing 'cookers', and other practices thought to decrease risk, such as rinsing injection equipment with water or disinfectant, were not found to be significantly associated with HIV infection in multivariable analyses.

One possible explanation for these null findings is that a particular drug behavior may have multiple effects on the risk of infection. For example, visibly contaminated needles and syringes are more likely than non-contaminated injection equipment to contain HIV seropositive blood (Wodak et al., 1987; Chitwood et al., 1990). By mechanically flushing virus particles from needle and syringe, rinsing equipment with water between injections may reduce the risk of infection in some instances. However, by increasing the 'use-life' of injection equipment without inactivating virus, water rinsing may increase the risk of infection in other instances (D. Des Jarlais, personal communication). In evaluating apparently null findings, it also is important to consider how the variables were measured. For example, in evaluating the risk to an individual of 'booting', it may be more relevant to gather information about this practice in users with whom the persons shares injection equipment, rather than to measure his/her own practice.

Subsequent to these earlier studies, an independent association between cocaine injection and HIV infection was identified (Chaissong et al., 1989; Friedman et al., 1989; Anthony et al., 1991b). According to the framework of earlier studies, which stressed quantification of needle-sharing behaviors, an association between cocaine injection and HIV infection was thought to be due to increased frequency of injection and sharing of equipment in persons who injected cocaine. However, the association between HIV infection and cocaine injection appears to be independent of injection frequency and sharing practices (Chaissong et al., 1989; Friedman et al., 1989; Anthony et al., 1991b). These findings generate hypotheses for future investigation, such as a direct immunosuppressive effect of cocaine, or a link between cocaine use and high-risk sexual practices (Weiss, 1989). In addition, as discussed later in this paper, the large number of injections associated with cocaine use may pose special problems in categorizing exposure levels.

Other investigators have suggested that HIV might be transmitted by other injection sharing practices which do not involve directly passing needles and syringes between individuals. For example, Wiebel et al. (1990) have noted that intravenous drug users report placing cotton into a 'cooker', using the cotton to filter out particulate matter when drug solution is drawn into a syringe. The cotton filter, impregnated with drug solution, is frequently saved and reused as a source of drug when street supply is low. If contaminated needles are placed into the cotton, then the filter might serve as a source of transmission of HIV. Grund et al.
(1990) noted a practice among intravenous drug users called 'frontloading', whereby drug purchased together by two or more users is 'cooked' into solution, drawn into one syringe and then divided by squirting a measured portion into other syringes. Clearly, this practice might involve transmission of contaminated blood, even when drug users report using only their own injection equipment. These points indicate a greater understanding of the concept of needle sharing, elaborating the list of factors to consider as intravenous drug users reduce the frequency of passing contaminated needles and the frequency of injecting with equipment rented or borrowed at 'shooting galleries'.

Another important consideration is the social network of the drug user. As noted in previous reports, the risk of HIV infection is related not only to the frequency of high-risk behaviors but also the group of individuals with whom the behaviors are shared (Des Jarlais et al., 1986; Schoenbaum et al., 1989; Vlahov et al., 1990). Frequency of a behavior, if practiced with uninfected individuals, might appear unrelated to HIV infection. Conversely, if practiced with infected individuals, the frequency of the behavior might appear strongly related to HIV infection.

Sexual transmission of HIV infection has received less attention than parenteral transmission in epidemiologic studies of intravenous drug users. The relative importance of sexual and parenteral routes of HIV infection in intravenous drug users is unknown (Haverkos & Edelman, 1988). Earlier studies had only limited measures of sexual behavior (Chaisson et al., 1987), and some investigators suggested that sexual transmission of HIV in intravenous drug users was probably insignificant compared to the risk of parenteral exposures (Tirelli et al., 1986). Subsequently, other investigators have reported that a proportion of HIV infection among intravenous drug users is related to sexual transmission, as measured by self-reported frequencies of specific sexual activities and markers of other sexually transmitted diseases (Schoenbaum et al., 1989; Nelson et al., 1991). In particular, a history of receptive anal intercourse has been associated with HIV infection in male intravenous drug users (Vlahov et al., 1990; Battjes et al., 1990). There is some evidence that the major route of HIV infection may shift from parenteral to sexual routes as intravenous drug users curtail their drug-use practices but continue sexual relationships with other intravenous drug users (Schoenbaum et al., 1989).

Study design
One of the major difficulties in conducting research on intravenous drug users is the lack of a sampling frame for the population under study. Given the general inaccessibility of drug users, convenience samples must be accepted. Participants for investigation of HIV-related risk factors in intravenous drug users have been identified primarily from two sources: drug abuse treatment centers and 'street outreach' (Vlahov & Polk, 1988).

The majority of studies reported to date have selected participants from drug abuse treatment centers (for example, Chaisson et al., 1987; Marmor et al., 1987; Selwyn et al., 1987; Schoenbaum et al., 1989; Novick et al., 1989; Magura et al., 1989). These sites can provide large numbers of drug users in a small number of locations, and they offer continuity of contact for follow-up investigations. In some respects, however, clients in treatment are apt to be different from those not in treatment (Vlahov & Polk, 1988; Rousville & Kleber, 1981).

Some studies have used 'street outreach' or 'chain referral' techniques to identify a group of intravenous drug users (e.g. Vlahov et al., 1990; Wiebel, 1988; Watters et al., 1986). Participants identified through 'street outreach' may represent a more diverse set of drug users than those in treatment. However, participants referred by other participants may be more similar to each other than participants recruited through other approaches (Vlahov & Polk, 1988). Other sources of intravenous drug users have included hospitals (e.g. Friedland et al., 1985; Chandrasekar et al., 1990), general practices (e.g. Robertson et al., 1986), and prisons (e.g. Vlahov et al., 1989).

The degree to which users from one setting differ from users in other settings with respect to demographic characteristics, risk practices, and prevalence of HIV infection has received limited study. McCusker et al. (1990) found significant differences in demographic characteristics, drug practices, and sexual behaviors between participants recruited from different settings in Worcester, Massachusetts, although the prevalence of HIV infection was similar across settings. In a sample of intravenous drug users recruited through street outreach in Baltimore, Alcubes et al. (1992) found differences in demographic characteristics and duration of drug injection between participants who were currently in drug treatment compared to those who were not in treatment. However, with the exception of race, the associations between many demographic
characteristics, drug practices, and HIV infection were not markedly different between the two groups.

The extent of bias in the estimated associations between risk practices and HIV infection due to selection of study participants is unknown. In light of this uncertainty, risk factors for HIV infection in intravenous drug users should continue to be investigated in a variety of settings. Consistency of findings across settings would add further support to etiologic hypotheses.

A useful approach for investigating behavioral risk factors for HIV infection in intravenous drug users is an incident cohort study. In this type of study, a sample of intravenous drug users is selected, and a group (cohort) of initially seronegative participants is identified. At baseline, the cohort is evaluated for sociodemographic characteristics and past and current drug use and sexual practices (or "exposures") that theory or prior empirical findings suggest might increase or decrease the risk of becoming infected with HIV. The cohort is followed prospectively, with periodic assessments for HIV antibody seroconversion and changes in risk practices. In this design, risk associated with selected practices can be examined, using seroconversion as the outcome measure.

Several advantages exist in studying incident (new) cases as opposed to prevalent cases (i.e. those already infected at the beginning of the study) (Rothman, 1986). First, risk practices preceding infection can be distinguished from practices following infection. In contrast, studies of prevalent cases cannot establish the temporal relationship between behaviors and infection. Secondly, incidence studies are able to disentangle risk factors for infection from correlates of prevalence (e.g. variables that influence survival in those infected). Studies of prevalent cases cannot. Thirdly, incidence studies can investigate the entire natural history of HIV infection, from onset of infection through pathological course to death, and allow identification of factors associated with progression. In studies of prevalent cases, the time since infection is unknown, so that the natural history of HIV infection can be assessed only since the time of enrollment into the study. This may result in biased estimation of factors associated with disease progression, as discussed by Brookmeyer et al. (1987).

Despite these advantages, incident cohort studies of HIV infection in intravenous drug users are difficult and expensive to conduct. A large number of participants must be followed for a considerable length of time before a sufficient number of seroconversions occur to yield precise estimates. Recruitment and retention of a sufficiently large sample of initially seronegative intravenous drug users may be extremely difficult (Vlahov & Polk, 1988). Furthermore, if loss to follow-up is correlated with both risk behavior and infection, biased estimates of the magnitude of the association can be obtained (Greenland, 1977). Moreover, a change in behaviors may occur over the course of the study, as the initially seronegative cohort responds to risk-reduction strategies.

Given these difficulties, most studies of HIV infection in intravenous drug users have been cross-sectional, with retrospective assessment of risk behaviors. In these studies, a sample of intravenous drug users is identified and a single HIV serostatus determined on participants. Past and current drug and sexual practices among seropositive and seronegative participants are compared. The odds of past infection in subjects exposed to particular factors, relative to the unexposed, can be estimated. As discussed above, prevalence studies cannot establish when infection occurred, making it more difficult to discriminate risk factors for infection from an array of potential prevalence correlates. Despite this limitation, studies involving prevalent cases of infection have provided the bulk of current knowledge about potential risk factors for HIV infection in intravenous drug users.

**Time frame of measurement**

Several considerations are involved in establishing the temporal relationship between risk behaviors and HIV infection in cross-sectional studies. First, conventional assays for antibody to HIV do not indicate whether onset of infection is recent or remote. Data from homosexual men indicate that the number of CD4 cells (the target cells of HIV infection) tends to decline in an orderly fashion over time, and therefore can serve as a crude measure of time since infection (Polk et al., 1987). However, quantification of CD4 cells is expensive and operationally difficult. In addition, preliminary analyses of the temporal decline in CD4 levels in samples of intravenous drug users have yielded contradictory results. Both faster and slower rates of CD4 decline in intravenous drug users, as compared with homosexual men, have been reported (Des Jarlais et al., 1987, Muñoz et al., 1988, Margolick et al., 1989).

Recently, techniques have been developed in which antibodies to specific HIV-1 antigens on the
Western blot assay are quantitated. Changes in antibody intensity may correlate with duration of infection (Schmidt et al., 1989). This procedure has the advantage of using only serum, and therefore not requiring collection of lymphocytes or quantification of CD4 cells. However, the procedure remains to be evaluated in intravenous drug users.

The difficulty in determining, from cross-sectional studies, when HIV infection was acquired raises the second issue of what time frames to consider for generating an historical reconstruction of risk behaviors. As a first step, it seems prudent to consider a range of calendar times during which HIV was present in the community. Although it is difficult to establish the appearance of HIV in a community, several approaches have been reported. One approach is to go back several years prior to the first reported case of AIDS in an intravenous drug user in each community. Another approach is to test stored sera to reconstruct temporal trends in the prevalence of infection (Des Jarlais et al., 1989). Another strategy is to test sera collected in the present from individuals who have ceased high-risk behaviors in an earlier calendar period. The inference is drawn that current prevalence of infection in those with remote risk activity probably reflects the prevalence of infection at the earlier calendar time (Schoenbaum et al., 1989; Vlahov et al., 1990).

A third issue is the consistency of drug-use behaviors over time. Whether individual patterns of drug practices are assumed to be stable over time, to progress to relatively more risky behaviors, or to become less risky over the course of an injection career affects decisions about time frames for measurement of risk behaviors. Studies on the natural history of intravenous drug use suggest tremendous variability in drug use patterns both within and between individuals (Nurco et al., 1975; Nurco et al., 1981; Brunswick & Boyle, 1979; Preble & Casey, 1969). This has led investigators to cover a long period of time in their assessment of HIV-related risk behaviors in intravenous drug users (Marmor et al., 1987; Schoenbaum et al., 1989; Vlahov et al., 1990).

Reconstruction of behavioral histories to cover an extensive period of time involves several important methodological considerations. One issue is the question of whether to ask respondents to provide a global summary of risk behaviors over a long period of time, or to have respondents recall details for each of several time periods within a more extensive time frame. The former strategy requires less effort, but the extent to which respondents weight their summaries of drug behaviors by recency of the behaviors or other factors cannot be evaluated by the investigator. Findings of several studies support the alternative strategy of collecting risk behavior information for each of several specific calendar periods. For example, Marmor et al. (1987) and Koblin et al. (1990) reported biologically plausible associations of HIV with relatively remote compared to most recent behaviors. Whether these findings reflect an effect of recent risk reduction efforts (subsequent to onset of infection), an effect of socially desirable responding for the most recent time period, or other factors remains to be determined.

A related issue is deciding where to begin the historical reconstruction of risk behaviors. Starting with the present and working backward in time has the advantage of beginning with a period for which accuracy and completeness of reporting is better than for more temporally distant periods. However, starting with a remote time period and working forward might help build rapport, in that the respondent may find it easier to discuss sensitive behaviors that occurred in the past. Whether one approach is superior in providing a more accurate historical reconstruction of intravenous drug use remains to be determined. The process of mistakenly importing information from one period to another has been found to occur in both directions, that is from past to present (‘telescoping’) and from present to past (‘distancing’ or ‘reverse telescoping’). This suggests that factors in addition to ordering of the temporal sequence of questions need to be considered in the design of historical reconstructions of behaviors (Sudman & Bradburn, 1974). For example, the use of important autobiographical landmarks, such as marriage or incarceration, to anchor historical reconstructions might improve the accuracy of temporal sequencing of behaviors (Bradburn et al., 1987).

Approaches to summarizing historical reconstructions of drug use behavior over extended periods of time have been varied. In the study of Marmor et al. (1987), respondents were asked to estimate average behaviors during two time periods (viz., 0–2 and 2–5 years prior to interview), taking into account changes within time periods. Schoenbaum et al. (1989) asked individuals to identify dates, anchored to significant life events, when patterns of drug use changed, and then summarized behaviors for each individually defined interval. In analysis, the behaviour of each respondent was summarized across intervals into an ‘average’ month. Vlahov et al.
(1990) asked participants to begin with the year 11 years prior to interview and to summarize behavior for that single year. Participants then were asked if behavior changed and to summarize behavior in the subsequent year. This process continued forward, year by year to the present. Analysis started with the most refined categories and proceeded to collapse empirically into broader calendar periods to generate cumulative patterns of drug injection behaviors over 11 years. Findings generally have been congruent across these progressively more complex approaches, and additional insight has been gained in the use of cross-sectional studies to describe the natural history of drug use and the HIV epidemic.

Categories of measurement

Directly related to the issue of time frames for measuring risk behaviors is the topic of response categories. As the time frame for response sets becomes shorter and more recent, more refined details about behaviors can be obtained. An exception to this may be the time period immediately surrounding initiation into drug use, which has been reported as being vividly recalled by intravenous drug users (Nurco et al., 1975; Hser et al., 1987; Gibbons et al., 1981). However, whether the time frame for response sets is recent or remote, selecting categories for responses involves several considerations.

First, the terminology used to describe behaviors needs to be considered. Smith et al. (1992) found extensive variation in the terminology used by a sample of 2921 intravenous drug users to describe drug injection practices. Respondents were asked to name practices described to them and pictured in a series of photographs. For each pictured behavior, the drug users reported over 30 different terms. For example, 46 different terms were reported for the practice of injecting drugs into a vein. In addition, the same term was often used by different users to describe different practices. For example, 'pumping' was used by some users to describe injecting drugs into a vein, and by others to describe repeated withdrawal and reinjection of blood. These findings emphasize the importance of designing questionnaires which explicitly describe various drug behaviors.

Some aspects of risk behavior may not be amenable to a photograph-assisted approach and may be a source of confusion for respondents or investigators. For example, the term 'shooting gallery' may connote to investigators an abandoned building, but actually may reflect a wide range of different settings, with a variety of levels of risk precautions and varying degrees of accessibility to different drug users (W. Wiebel, personal communication). Although use of a typology for shooting galleries might clarify this issue, another approach is to present study subjects with descriptions of behaviors (e.g., 'a place where a drug user goes to rent or borrow needles') in combination with a label (i.e., 'shooting gallery'). This latter approach is important to consider for culturally stigmatized behaviors, such as male homosexuality within minority communities. For example, asking a respondent whether he had 'ever had sex with another male in exchange for drugs or money' may be less threatening than asking him to label himself a 'homosexual' or 'prostitute'.

A second issue is how to obtain information about the frequency of a particular behavior. This issue involves several considerations. First is whether to ask if a particular behavior has been done ever. Posing a question as ever/never has several advantages. For example, when a person reports having injected drugs at some time in the past, it is possible to probe for details about the behavior. In addition, it allows both the interviewer and respondent to skip questions about behaviors reported as 'never' performed, thereby shortening an interview and focusing the respondent on the behaviors in which he/she engaged. The major disadvantage, however, is that respondents may learn to say 'never' simply in order to shorten what they perceive to be a lengthy or highly sensitive set of questions.

A second consideration related to questions about frequency of behaviors is the selection of measurement scales. The spectrum of possible responses ranges from continuous scales (e.g., analogue ratings) to dichotomies (i.e., yes/no). Although a continuous or ordinal scale, such as the number of injections in the previous month, might appear to allow increased precision, this approach places heavy demands on the respondent. The level of detail required by continuous scales may exceed the capabilities of respondents, may lead to frustration, and may simply represent 'average' or 'typical' experiences. Further, because there is tremendous variability in drug injection practices both within and between drug users, responses are usually categorized for statistical analyses, after diagnostic procedures are used to detect possible non-linearities.

Questions about the frequency of injection behavior also need to take account of the type of drug
used. For example, cocaine has a shorter half-life and tends to be injected more frequently than heroin, often in binges or sprees of injection. A heroin user may inject once a day for weeks on end, whereas a cocaine user may inject seven times in a single day but only one day each week. In this example, both the heroin and cocaine injectors may report seven injections per week, but the patterns of injections are qualitatively different. In addition, recalling the frequency of cocaine use may be difficult, because closely spaced injections may not be discriminated by the user.

Another consideration in evaluating the frequency of behaviors relates to measuring the proportion of time an activity was performed. Although an ideal might be to have individuals report ‘percent’ (such as, the percent of injections in which needles were shared), this involves a mathematical concept that can exceed the capability of many drug users. As noted above in the discussion of continuous scales, frustration and other psychological factors may induce respondents to attempt precise responses that ultimately are invalid. Studies of intravenous drug users have tended to use a scale of ‘never’ and ‘always’ at the extremes and several intermediate categories (e.g., ‘less than half the time’) to quantitate the proportion of injections in which a certain practice (e.g., needle sharing) was employed. The specification of an optimal scale for quantititing risk behaviors among intravenous drug users remains a topic for future research.

Validity of self reports
Given the private nature of many of the risk behaviors under investigation in AIDS research, information often can be provided only by individuals about their own behaviors. However, intravenous drug users may provide inaccurate information about their past and current behaviors (Harrell, 1985). On the one hand, the respondent may be unable to recall past behaviors. As discussed above, patterns of sexual and drug use practices that are quite complex and may have undergone changes over time may be extremely difficult to recall accurately (Bradburn et al., 1987). Some studies have not found differences in neuropsychological test results between seronegative and asymptomatic HIV seropositive individuals (Selnes et al., 1990). However, inability to remember may be problematic in a proportion of HIV infected persons who develop early neuropsychiatric manifestations (Perry, 1990). In addition, psychological impairments attendant to infection and illness, such as anxiety and depression, may compromise accurate recall of past behaviors (Joseph et al., 1990). On the other hand, respondents may be quite capable of remembering but extremely unwilling to reveal sexual and drug use practices that are stigmatized and even illegal (Siegel & Bauman, 1986). Whether unintentional or deliberate, invalid self-reported information about risk practices can bias the esti-
mates of the magnitude of the association between these behaviors and HIV infection.

Despite these concerns, a variety of different approaches have shown that intravenous drug users often provide reasonably accurate self-reports of their drug use behaviors. One approach to validating self-reported drug use behaviors is to compare these reports against some other source of information. Most commonly, this source of information has been urinalysis (for example, Amsel et al., 1976; Bale, 1979; Bale et al., 1981; Magura et al., 1987). Others studies have used official records (for example, Bonito et al., 1976; Maisto et al., 1982-83) or acquaintances of the drug user (for example, Aiken & LoSciauto, 1985; Stephens, 1972; Rounsaville & Kleber, 1981). These studies generally have found reasonably good agreement between self-reported information about drug use and data obtained from other sources. Indeed, self-reported drug use information may be more accurate than information available from these other sources.

A second approach to validation is to measure the degree of socially desirable responding (Harrell, 1985). Instruments to measure this construct have long been available (Crowne & Marlowe, 1960). A more recent instrument attempts to distinguish self-deception (in which the respondent believes his/her self-reports) from impression management (in which the respondent deliberately attempts to deceive the interviewer) (Paulhus, 1984). The utility of these instruments in studies of intravenous drug users and HIV infection is currently under investigation (Vlahov et al., 1991).

Another approach to validation has been to compare self-reported drug use with physical evidence of injection. For example, in a sample of Baltimore intravenous drug users, Anthony et al. (1991a) noted a positive association between needle marks on upper extremities and reported frequency of injection in the six months prior to interview. In a study of prisoners, Vlahov (1988) found that agreement between self-report and upper-extremity needle marks varied by race and age. The degree of agreement was lowest in young blacks. The possibility of differential reporting of drug use according to race is important, given that several studies have reported increased prevalence of HIV infection in minorities, even after controlling for self-reported drug use practices (Chaisson et al., 1987; Chaisson et al., 1989; Schoenbaum et al., 1989). This line of inquiry can be extended in future studies by measuring the number of extremities with stigmata of injections, as well as the number of discrete needle marks.

A fourth approach has investigated construct validity by comparing self-reported drug use with immune parameters associated with HIV-1 infection. Based on data reported by Des Jarlais et al. (1987), an association between injection frequency and the rate of decline in the number of CD4 cells was hypothesized. As expected, Friedman et al. (1988) found that seropositive intravenous drug users who reported reduced needle-sharing had higher CD4 counts than did those not reporting reduction in needle-sharing. Similarly, based on reports of decline in CD4 levels over time (Moss & Bacchi, 1989), it was hypothesized that seropositive persons with lower CD4 levels would report a remote period of high-risk activity. As expected, Anthony et al. (1991a) found that seropositive intravenous drug users with lower CD4 counts had longer-standing histories of needle-shared injections. Evaluating construct validity with measures of other immune parameters should provide additional opportunities to validate self-reported drug use practices in intravenous drug users.

Conclusions

The AIDS epidemic has created an explosion in knowledge about drug injection and sexual practices among intravenous drug users, as well as methodological approaches for measuring these behaviors. Early ethnographic data on the routes of drug administration and details of drug injection practices have been extended through epidemiologic studies of intravenous drug users. Through these studies, conducted over the past 10 years in response to the AIDS epidemic, much has been learned.

New findings have accumulated by means of this research, such as the evidence on positive associations between blood-borne infections (e.g. HIV) and specific injection practices, such as use of 'shooting galleries' and sharing needles with a number of different partners. These associations are biologically plausible, reasonably strong, and consistently identified across studies that have used different methodological approaches in different populations. Other aspects of the linkage between drug injection practices and HIV infection are less well characterized but appear to be important, such as the dynamics of social networks and the relevance of sexual practices in intravenous drug users. Still other aspects remain conjectural, such as the role of
sharing 'cookers' and the practice of 'frontloading' in relation to HIV infection.

Research to date has focused on cross-sectional studies of correlates of prevalent HIV infection. More prospective studies are needed. Such studies will allow investigation of factors involved in HIV seroconversion, and progression to AIDS after infection, in intravenous drug users. Of great interest from a public health standpoint is the impact of behavioral changes over time on the risk of infection and progression to AIDS.

Furthermore, future studies are needed to determine how drug users selected from various settings are different, and how these differences influence the estimated associations between risk behaviors and HIV infection. For example, the severity of drug dependence may help explain differences in the prevalence of HIV infection in drug users drawn from treatment agencies versus other settings. To explore this possibility, it would be useful to measure the severity of drug dependence as a determinant of HIV infection (McLellan et al., 1980).

In addition, more research is needed regarding the methods required to obtain precise, accurate reconstructions of behavioral histories in intravenous drug users over extended time periods. It would be useful, in designing interviews, to learn how intravenous drug users reconstruct their behavioral histories in their own minds, what mental processes are used to recall past behaviors, and what interview techniques aid recall. In addition, drug abuse researchers need to learn how to describe risk behaviors in terms that are uniformly interpreted by respondents, as well as how best to categorize and scale risk behaviors in intravenous drug users.

Finally, further validation of information provided by intravenous drug users about their sensitive behaviors is indicated. Studies should continue to explore laboratory measures, physical observations, social desirability response scales, and other strategies to validate information provided by drug users about their behaviors. In addition, drug abuse researchers need to determine characteristics of the interviewer and interview setting that maximize collection of accurate and precise information.

The HIV epidemic has changed the way drug abuse researchers conceptualize drug use and other intimate behaviors. The importance of eliciting the details of drug and sexual patterns has been underscored, and strategies for measuring these behaviors have been developed. Attempts to come to terms with measurement issues in the context of HIV infection in intravenous drug users should lead to the further development of methods for use in the general context of drug abuse research.

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