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Needle-Exchange Participation, Effectiveness, and Policy: Syringe Relay, Gender, and the Paradox of Public Health

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ABSTRACT *Needle-exchange programs (NEPs) have been politically controversial, and most studies have focused on evaluating their effectiveness on human immunodeficiency virus (HIV) transmission rates with little emphasis on the process of how they are used. This article shows that the way intravenous drug users use NEPs may influence their effectiveness. Using data from Baltimore's NEP, participants (N = 2,574) were classified as low, medium, and high users based on the volume, frequency, and duration of contact with the NEP. Higher NEP use was associated with shorter syringe circulation times and less syringe relay, returning syringes to the NEP originally acquired by someone else. For a subsample that was HIV tested (N = 262), syringe relay among women was associated with HIV seroconversion (at a 95% confidence interval). We conclude that exclusive use of the NEP (no relay) provides greater HIV protection than NEP use involving syringe relay. The paradox is that public health goals will not be achieved by prohibiting syringe relay activities and promoting exclusive use. NEPs should broaden their education efforts to have participants understand the value of repeated visits to the NEP.*

INTRODUCTION

Needle-exchange programs (NEPs) were initially developed clandestinely with marginal resources and frequent political resistance over the past 15 years. In the past decade, more formalized programs have been developed, accompanied by more rigorous evaluation. For the most part, NEPs have been shown to be effective in preventing parenteral transmission of human immunodeficiency virus (HIV) infection among injection drugs users (IDUs).[1–6] NEPs are designed[7] to reduce HIV risk by (1) increasing circulation of sterile syringes in an IDU community and reducing the circulation time of possibly contaminated syringes and (2) providing programs designed to promote individual HIV prevention behaviors. In some ways, these two goals are somewhat contradictory since focusing on syringe circulation implies a population public health perspective in which effectiveness is based on increased access to clean syringes, with less emphasis on individual behavioral change. In

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contrast, NEP behavior change programs focus on individual protection, encouraging repeated individual contact with NEPs for behavioral change counseling and HIV service referral, in addition to getting clean needles.

These parallel goals have led to two types of needle-exchange activities, exchange for exclusive use and secondary exchange. Exclusive users acquire syringes at the NEP primarily for their own personal use. Exclusive users can derive the most benefit from the NEP since they get clean syringes and repeated counseling for behavior change. NEPs that expect exclusive use, however, have two limitations: (1) IDUs usually consume drugs and socialize in networks,[8–11] so users will want to exchange syringes for one another as well, and (2) exclusive exchange is not an efficient way to get clean syringes to a large number of users.[12] These limitations have prompted many NEPs to tolerate secondary and satellite exchange, but for different reasons.

Secondary exchange occurs when a network of IDUs sends one person to the NEP to get needles for the group. The disadvantage to secondary exchange is that only the index person develops sustained contact with the NEP and access to the ancillary services it provides. Moreover, the information received at the NEP by the index person is not reinforced by other nonattending network members. If network members take turns attending the NEP, it dilutes the effect of individual contacts. These disadvantages are further exacerbated by satellite exchange.

Satellite exchange occurs when NEP participants acquire a high volume of syringes to sell or trade outside their personal network in neighborhoods distant from the exchange.[12] Satellite exchange is conducted by individuals who are either highly altruistic or entrepreneurial who take syringes to locations not reached directly by the NEP. Satellite exchange provides a public health function by getting clean syringes into the community and dirty used syringes back to the exchange site. This macrolevel impact provides a "blanket of protection" by reducing the time syringes circulate in a community.

The paradox for NEPs is that they should encourage exclusive use to promote the individual benefits of NEP participation, but must also tolerate, and perhaps encourage, secondary exchange to meet public health goals. Exclusive use yields more contact time with NEP staff trained in HIV prevention and treatment referral. NEP impact is then demonstrated, with increased knowledge and skills among those who visit the program frequently.[1] Secondary exchange yields less direct contact with NEP staff for most users, yet more potential impact at the community level. This impact may be demonstrated by aggregate decreases in the circulation time of used syringes and/or a reduction in HIV incidence or prevalence at the community level.[13]

A key evaluation question for NEPs, then, is to show how they work at both the individual and community levels and how to improve outcomes at both levels. Understanding how and for whom NEPs are differentially effective may provide some guidelines to improve their operational effectiveness. This article determines the extent NEP use was associated with exclusive versus secondary exchange and how it was associated with syringe circulation times. We then link these use patterns to data on HIV seroconversion for a subsample. It was hypothesized that exclusive users, because of less contact with others and more direct sustained contact with the program staff, are more likely to derive individual benefit from the NEP, as measured by HIV seroconversion.

It is not possible to measure exclusive use explicitly since it would require a complete trace on each needle distributed to an IDU to determine whether it was

used by a participant and then returned or whether it was given, traded, or sold to others. It would also require that we then determine whether this other person was a member of the NEP participant's immediate social circle and whether this other person also visited the NEP. Consequently, exclusive use was measured by a proxy that indicates the degree that a NEP participant returned personal syringes or those initially distributed to someone else.

To measure NEP exclusive use, we introduce the concept of "syringe relay." *Syringe relay* refers to returning syringes to the NEP that were originally issued to someone else. Individuals who engage in syringe relay do not return the syringes they were given, but rather return ones from a variety of people and/or sources. Exclusive users will have low levels of syringe relay since they will return syringes they acquired originally. The technique used to measure syringe relay is borrowed from Kaplan and Heimer's method of affixing bar codes to the syringes distributed by specific NEPs.[14,15]

In the Baltimore Needle Exchange Program (BNEP) in Maryland, syringes are provided at three locations on a one-to-one exchange basis with no limit. To evaluate the impact of BNEP use patterns, participants were categorized based on the volume, frequency, and duration of their BNEP use. We then determined the factors associated with BNEP use and whether the BNEP was differentially effective for different users. The general model tested was whether BNEP use influences syringe circulation time and syringe relay behavior, both of which were expected to influence the incidence of HIV infection.

METHODS

Sample

There were 5,369 participants who visited the BNEP at least once during the 30-month period from August 1994 to February 1997, a period when all distributed syringes were individually bar coded. From this group, participants who visited the BNEP only once (n = 1,910), participants who did not return any program needles issued at the BNEP (n = 873), and participants who were missing any sociodemographic information collected at their registration interview (n = 12) were eliminated from the analysis. The final sample consisted of 2,574 BNEP participants who visited the BNEP on more than one occasion and returned syringes issued by the NEP.

From the total BNEP participant list, 484 (9%) individuals were systematically recruited into a subsample cohort that was voluntarily and repeatedly tested for the HIV antibody. In this subsample, 141 (29.1%) were HIV seropositive at enrollment and thus were eliminated from analysis, and an additional 81 (16.7%) did not return any BNEP syringes and also were eliminated from analysis. The final tested subsample consisted of 262 participants who were periodically and voluntarily tested for HIV, were seronegative on enrollment into the BNEP, and returned at least one program syringe. There were 12 participants (4.6%) who seroconverted over the 30 months, yielding a 1.8% person per year rate.

Questionnaire

On enrollment, participants were administered a short registration questionnaire that measured sociodemographic characteristics such as sex, age, cohabitation status (whether the participant lived with someone), whether the person lived in his

or her own residence, race, and employment status. The questionnaire also asked about frequency of drug use within the prior 2 weeks and collected information on speed, cocaine, heroin, "speedballing" (i.e., combining heroin and cocaine in the same syringe), and any other drugs. Frequencies were then averaged into a drug use frequency scale. For the tested subsample, dates of the HIV test were included in the analysis since participants who were in the study longer had more opportunity to become HIV infected (surveillance bias).

Baltimore Needle Exchange Program Use

Use of the BNEP was measured by dichotomizing the following three use variables[16] on their median: (1) volume, the total number of syringes exchanged at the NEP (median = 94 needles); (2) frequency, the number of visits to the NEP (median = 5 visits); and (3) duration, the number of days between first and last visits (median = 262 days). We defined BNEP use as low, below the median on all three indicators (n = 770, 29.9%); medium, below the median on any one of the three indicators (n = 941, 36.6%); and high, above the median on all three indicators (n = 863, 33.5%). For multivariate analysis, we converted all three indicators to standardized *z* scores and summed them to get a standardized variable called BNEP use.

Syringe Relay and Circulation

Data were also collected linking individual identification (ID) numbers and the unique bar codes affixed to the syringes acquired and returned. These data allowed us to create a matrix of linkages in which each cell represents whether two individuals ever acquired and/or returned the same needle. For example, persons with ID 24 and ID 18 in the study could be linked by five needles that person 24 acquired and person 18 returned and by nine needles that person 18 acquired and person 24 returned. In addition, each person in the study can be characterized by the number of needles that person acquired and returned with no (presumed) intermediaries. From these data, we created a dummy variable, syringe relay, that indicated participants who only returned syringes originally issued to someone else. We also created a variable, circulation time, which is the average number of days the syringes issued to a participant circulated before being returned to the BNEP. (Circulation time could also be calculated using the number days a needle circulated that was returned by the participant or the average of the two.) Syringe relay and circulation time were used to test hypotheses concerning the effectiveness of BNEP use.

RESULTS

Table 1 shows the demographic characteristics of the samples. Most of the participants were male (72.0%), were older than 35 years (81.3%), lived alone (68.8%), did not live in their own residence (61.1%), were African American (89.9%), were unemployed (91.9%), and were daily drug users (49.1% used once a day or more frequently). Syringes circulated in the community an average of 29.4 days. Of the sample, 31.1% were syringe relayers. The demographic characteristics of the tested subsample were similar to those of the larger sample.

The 2,574 participants acquired an average of 275 (SD = 592) needles during an average of 13 (SD = 19) visits over the 30-month period of study. (The data on the number of syringes acquired were derived from the records of needles that were bar coded and eventually returned to the BNEP. These syringes represent only about a third of the syringes distributed during this period; the other bar coded

TABLE 1. Demographic characteristics

Characteristic	All participants (N = 2,574), n (%)	Evaluation subsample (N = 262), n (%)
Gender		
Male	1,853 (72.0)	176 (67.2)
Female	721 (28.0)	86 (32.8)
Age, years		
22–35	483 (18.8)	51 (19.5)
36–45	1,271 (49.4)	130 (49.6)
46+	820 (31.9)	81 (30.9)
Cohabit		
No	1,775 (69.0)	170 (64.9)
Yes	799 (31.0)	92 (35.1)
Live in own residence		
No	1,574 (61.1)	152 (58.0)
Yes	1,000 (38.9)	110 (42.0)
Race		
White and other	260 (10.1)	28 (10.7)
Black	2,314 (89.9)	234 (89.3)
Employment		
No	2,366 (91.9)	236 (90.1)
Yes	198 (7.7)	22 (8.4)
Frequency of drug use		
Less than 1 per week	414 (16.1)	45 (17.2)
1–6 times per week	891 (34.6)	81 (30.9)
Once a day	1,003 (39.0)	108 (41.2)
More than once a day	266 (10.3)	28 (10.7)
BNEP use		
Low	770 (29.9)	81 (30.9)
Medium	941 (36.6)	98 (37.4)
High	863 (33.5)	83 (31.7)
Syringe relayers	800 (31.1)	73 (27.9)
Average days circulation (SD)	29.4 (25.1)	27.9 (23.1)

"All participants" are Baltimore Needle Exchange Program (BNEP) participants at registration who visited more than once and returned at least one program syringe; and for the evaluation subsample were periodically tested for HIV, were seronegative on enrollment, and returned at least one program syringe.

syringes were not returned.) The average number of days from the first to last visit was 315 (SD = 254). Of the 2,574 participants, roughly a third were classified into each use category, with 29.9% low users, 36.5% medium users, and 33.6% classified as high users.

Table 2 reports associations between BNEP use and demographic characteristics. BNEP use was not associated with gender, cohabitation status, residential status, or race. For example, 71.3% of low users and 70.8% of high users were male. Age, however, was significantly different among groups: Low users were younger than medium or high users. Employment and drug use frequency were also signifi-

TABLE 2. Baltimore Needle Exchange Program utilization status by demographic, drug use frequency, syringe relay, and syringe circulation time

	Low	Medium	High
All participants (N = 2,574)			
Total	770 (29.9)	941 (36.6)	863 (33.5)
Female, %	28.7	26.3	29.2
Average age,* years	40.4	41.1	43.0
Cohabit, %	32.7	29.8	30.9
Live in own residence, %	37.7	37.6	41.2
African American, %	88.5	90.2	90.8
Employed,† %	9.3	8.2	5.8
Average drug use frequency†	2.12	2.18	2.24
Syringe relayers,* %	60.2	31.9	4.2
Syringe circulation time,* days	31.2	30.3	26.8
Evaluation subsample (N = 262)			
Total	81 (30.9)	98 (37.4)	83 (31.7)
Female, %	24.7	32.7	41.0
Average age, years	40.4	40.8	41.5
Cohabit, %	37.0	34.7	33.7
Live in own residence, %	40.7	39.8	45.8
African American, %	84.0	91.8	91.6
Employed, %	9.1	11.2	4.8
Average drug use frequency	2.17	2.17	2.23
Syringe relayers,* %	59.2	23.5	2.4
Syringe circulation time, days	27.8	31.1	24.3

*$P < .001$.
†$P < .05$.

cantly different among groups, with high users reporting more frequent drug use and lower employment rates than medium or low users.

Syringe relay was significantly different among groups: 60.2% of low BNEP users were syringe relayers, while only 4.2% of high BNEP users were syringe relayers ($P < .001$). Circulation time was significantly different, but modest, among groups: The needles of low BNEP users circulated an average of 31.2 days, while those of high BNEP users circulated an average of 26.8 days ($P < .001$). Thus, low users were more likely to return syringes originally distributed to someone else, and those syringes circulated in the community about 4 days (14%) longer.

Results for the evaluation subsample were similar to those of the larger sample, but some relationships previously statistically significant were not statistically significant (perhaps due to the smaller sample size). For example, high users had an average older age, but the difference was not statistically significant. Bivariate differences were also statistically insignificant for employment, drug use frequency, and circulation times. Syringe relay remained statistically significantly associated with BNEP use for the evaluation subsample, with 59.2% of low users being syringe relayers compared to only 2.4% of high users.

Table 3 reports a multivariate analysis of BNEP use (standardized average of

TABLE 3. Standardized multivariate regression coefficients for Baltimore Needle Exchange Program use

	All participants (N = 2,574)	Evaluation subsample (N = 262)
Female	−.01	.06
Age categorized	.09*	.09
Cohabitation	−.01	−.01
Live in own residence	.02	.10
African American	.02	.02
Employment	−.02	.01
Drug use frequency	.05†	.07
Duration in study	NA	.27*
Syringe relayer	−.31*	−.38*
Syringe circulation time	−.04*‡	−.02
Adjusted R^2	12%	25%

NA, not applicable.
*$P < .001$.
†$P < .01$.
‡$P < .05$.

the BNEP use variables)* predicted by gender, age, cohabitation status, residence status, race, employment, drug use frequency, syringe relay, and circulation time. The results are consistent with the bivariate analysis in that age, reported drug use frequency, syringe relay, and circulation time were significantly associated with BNEP use. Participants who were older and more frequent drug users were higher users of the BNEP. In addition, participants who returned their own syringes and who returned them more quickly used the BNEP more.

The evaluation subsample multivariate regression produced similar results, but the associations between BNEP use and age and drug use frequency again were not statistically significant. Duration in study was significantly associated with BNEP use, which derives from the fact that both duration and BNEP use are measured, in part, by how long the participant had been in contact with the BNEP. Syringe relay was also negatively associated with BNEP use in the evaluation subsample ($\beta = -.38$, $P < .001$).

Table 4 analyzes the association between BNEP use and HIV seroconversion for the tested subsample. None of the sociodemographic characteristics was associated with HIV seroconversion during the study period. Duration in the study was significantly associated with HIV seroincidence (odds ratio [OR] = 2.06), indicating that participants who seroconverted were more than two times as likely to do it in later tests rather than earlier ones, as expected. BNEP use was not associated with seroconversion, nor was circulation time, indicating that more BNEP use and more rapid return of syringes did not directly lower the individual likelihood of becoming HIV positive. The odds ratio for HIV seroconversion and syringe relay was 2.73, indicating that participants who returned syringes originally acquired by someone

*BNEP use was created by standardizing the variables volume, frequency, and duration to have a mean of 0 and a standard deviation of 1 (converted to z scores). We then calculated the average of the three standardized variables to obtain BNEP use that had a mean of 0 and a standard deviation of 0.85.

TABLE 4. Bivariate logistic regression for likelihood of seroconversion (N = 262)

Characteristics	Odds ratio	95% Confidence interval
Female	1.49	0.46–4.84
Age categorized	1.06	0.88–1.19
Cohabit	1.34	0.41–4.34
Live in own residence	0.99	0.30–3.19
Frequency of drug use	1.64	0.68–3.98
Duration in study	2.06	1.24–3.42
BNEP use	1.18	0.65–2.15
Syringe relayer	2.73	0.85–8.76
Circulation time	0.98	0.93–1.02

BNEP, Baltimore Needle Exchange Program.

else were 2.73 times as likely to seroconvert during the course of the study (the confidence intervals for syringe relay included one thus not significant at the 95% level, but excluded one thus significant at the 90% level) than those who returned their own syringes. As we see below, however, this marginal significant risk is misleading since the risk occurs predominantly for women.

In the multivariate model that includes sex, duration in study, and syringe relay, we found that both duration in the study and syringe relay were significantly associated with HIV seroconversion. The sex and syringe relay variables interacted with one another. Table 5 reports multivariate analysis of HIV seroconversion on duration in study and the four interaction terms constructed from sex and syringe relay. There was no difference in seroconversion for relay males compared to nonrelay males and no difference in seroconversion for nonrelay females compared to nonrelay males. There was a significant difference in seroconversion among relay females compared to nonrelay males (Table 5, adjusted OR = 8.53). Indeed, seroconversion for relay females compared to relay males was significantly higher (OR = 7.96, 95% CI = 1.18–53.69). Thus, the only risk for seroconversion was among women who relayed syringes. This finding merits discussion.

DISCUSSION

The IDUs who used the BNEP more (defined as a composite of frequency, volume, and duration) returned syringes somewhat more quickly and returned syringes

TABLE 5. Multivariate logistic regression for likelihood of seroconversion

Characteristics	Adjusted odds ratio	95% Confidence interval
Duration in study	2.45	1.36–4.42
Male, no relay (reference)	1.00	—
Male, relay	1.07	0.19–6.00
Female, no relay	0.36	0.04–3.22
Female, relay	8.53	1.83–39.79

much more often if they personally had acquired them originally at the BNEP. This suggests that the exclusive users of the BNEP are likely to benefit directly from their contact with it.

Few of the evaluation subsample participants became HIV infected (n = 12); hence, our data regarding HIV seroconversion are only suggestive. We found that BNEP use was not significantly associated with a decrease in the likelihood of becoming seropositive. Syringe relay, however, was associated with becoming HIV positive for women only. That is, women BNEP participants who returned syringes to the BNEP that were originally acquired by someone else were more likely to become HIV infected than those who returned their own syringes. Hence, BNEP use provided the best protective effect for those who use the exchange exclusively to obtain and return their own syringes. Perhaps this is due to the fact that women syringe nonrelayers are using syringes exclusively themselves or within small, closed drug-using networks and are at less risk for contracting HIV. Women relayers may be returning syringes they used after a male partner had acquired them from someone else or somewhere else.

While the ideal for a NEP might be to promote purely exclusive use, it is recognized programmatically that more people can be served by permitting secondary and satellite exchange. According to Kaplan's circulation theory,[17] wider syringe distribution should decrease circulation time and therefore decrease HIV risk at a population level. However pragmatic, there must be caution in permitting secondary and satellite exchange as these activities result in IDUs getting clean needles, but not HIV prevention services; thus, they may be as likely as before to share or trade needles.

Conclusions cannot be drawn about the impact of secondary and satellite exchange on HIV transmission since this analysis was performed using data from a NEP, and there was no means to bar code and collect needles from circumstances outside the NEP. Thus, the results of this study in no way undermine or contradict Kaplan's circulation theory.[17] Rather, the results suggest that exclusive users (defined as persons returning their own syringes) have a lower risk of seroconversion when compared to NEP users who return syringes initially issued to someone else. Therefore, efforts to encourage exclusive use are prudent from a public health perspective.

Importantly, syringe relay was a risk factor only for women. Women who engaged in syringe relay were more likely to seroconvert during the study than their nonrelaying peers, but men were not. This indicates that women who return syringes acquired by others may be putting themselves at increased risk by not restricting their drug use to themselves or small closed networks. Other research has shown that women IDUs who share syringes with sexual partners may be at greater risk for HIV infection, and this may be one of the factors driving the association seen here.[18] Future research is needed to investigate reasons why the HIV risk is so much higher among women who relay syringes than among men who do.

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