The influence of neighborhood socioeconomic disadvantage and social discomfort on high-risk injection behavior among people who inject drugs

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Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
under the Executive Committee
of the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2016

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ABSTRACT

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Research on the determinants of injection drug use behavior has traditionally concentrated on factors operating at the individual level. However, more recent studies have found that behaviors surrounding injection drug use are shaped, not only by individual-level characteristics, but also by the environment in which they occur. The risk environment paradigm, proposed by Rhodes and colleagues, describes how factors exogenous to the individual influence high-risk injection behavior and blood borne virus (BBV) transmission among people who inject drugs (PWID). To date, few elements of the risk environment have been evaluated as potential determinants of high-risk injection behavior. The purpose of this dissertation was to study the influence of two elements of the risk environment on unsafe injection practices among PWID – neighborhood socioeconomic disadvantage and social discomfort surrounding the acquisition of sterile syringes from syringe exchange programs (SEPs) and pharmacies. To this end, a systematic literature review was conducted on the relation between neighborhood context and injection drug use behavior. Research gaps and methodological challenges identified in this review were used to design analyses exploring relations among neighborhood disadvantage, social discomfort, and high-risk injection behavior. These analyses were conducted using data collected from 484 PWID enrolled in the Pharmacists as Resources Making Links to Community Services (PHARM-Link) study, combined with data from the American Community Survey. Poisson regression with robust error variance was used to estimate associations between measures of neighborhood socioeconomic disadvantage and high-risk injection behavior. SEP accessibility and drug-related police activity were evaluated as potential modifiers of these relations. Similar methods were used to estimate associations between measures of social discomfort and high-risk injection behavior, including neighborhood socioeconomic disadvantage as a potential effect modifier. The systematic literature review on neighborhood context and injection drug use behavior identified few articles pertaining to this relation (n=22). Selected studies primarily investigated the influence of structural aspects of the neighborhood environment on behaviors surrounding injection drug use, while aspects of the social environment and potential modifiers of

neighborhood-behavior relations were understudied. Subsequent quantitative analyses revealed that neighborhood socioeconomic disadvantage was associated with safer injection behaviors among PWID. Injectors in disadvantaged neighborhoods reported less receptive syringe sharing and less unsterile syringe use than their counterparts in relatively better off neighborhoods. Drug-related police activity attenuated associations between neighborhood disadvantage and unsterile syringe use, while the direction of associations between neighborhood disadvantage and the use of unsafe syringe sources varied with levels of SEP accessibility. In neighborhoods with high SEP accessibility, neighborhood disadvantage was associated with decreased use of unsafe syringe sources, while in neighborhoods with low SEP accessibility, neighborhood disadvantage was associated with increased use of unsafe syringe sources. Social discomfort was not associated with high-risk injection behavior, but effect modification was detected between neighborhood disadvantage and two items measuring the quality of relationships between participants and syringe staff: “Pharmacists care about my health and well-being” and “The staff at syringe exchange programs seems to care about my health and well-being.” In disadvantaged neighborhoods, participants who reported positive relationships with syringe staff were less likely to engage in receptive syringe sharing. However, in relatively better off neighborhoods, positive relationships with syringe staff were associated with increased receptive syringe sharing. Overall, the results of this dissertation support the validity of the risk environment paradigm in shaping high-risk injection behavior among PWID. Future studies should continue to investigate contextual factors as determinants of behavior surrounding injection drug use. Understanding how aspects of local-area environments influence injection risk behavior will be essential to eliminating the transmission of BBVs among PWID.

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ACKNOWLEDGMENTS

Although my name happens to appear on the title page of this document, this dissertation would not have been possible without the guidance and support of many kind faculty, friends, and family. I have to begin by thanking the members of my dissertation committee, without whom I would have been unable to navigate my way to a defense:

To Crystal Fuller Lewis – Thank you for serving as my dissertation sponsor and for guiding me through the process of developing my aims.

To Gina Lovasi – Thank you for teaching me to be an epidemiologist. No matter how many questions I asked you about methods and data analysis, you always gave me kind and thoughtful answers. I am forever grateful to you for being so generous with your time and for your willingness to share your extensive knowledge with me.

To Abdul El-Sayed – Thank you for giving me the confidence I needed to push this project forward. Your support has been hugely instrumental in moving this project toward a conclusion.

To the remaining faculty who participated in my proposal defenses and now my dissertation defense, Bruce Link, Sherry Deren, Larry Yang, and Dana March – Thank you for your participation and your comments. Your input has undoubtedly improved the quality of this work.

As much as I have relied on faculty to help me through the challenges of assembling this dissertation, I have also relied on friends.

To Tais Farahmond – Thank you for your undying support throughout this process. I feel so lucky to have experienced the last 15 years with you, and I look forward to making many more memories.

To Vandhana Rao – You have been with me through this process from start, and I will always be grateful for your support. Thank you for all of the long phone calls and the days spent running around NYC over the past eight years. I look forward to celebrating this victory with you soon.

To Austin Chiang – Thank you for sharing so many adventures with me, not only in NYC, but around the world. I look forward to our next trip.

To Natalia Mendoza – My lovely roommate and great friend. I was so lucky to have you through the first half of this process.

To Rahma Mkuu – Thank you for your bright and uplifting personality. You have been such a wonderful presence in my life, and I hope to return the favor by supporting you through your PhD program.

To Ruth Stefanos and Nayema Khan – Thank you for welcoming me into 20E. The apartment has not been the same since you left.

Finally, the biggest thanks go to my family. None of this would have been possible without you. You have always supported me as I pursued my goals, and I cannot help but view this moment as a victory for all of us.

To Mom and Dad – Thank you for all of your pep talks. You have been with me on this journey every step of the way, and I look forward to celebrating with you in Europe next month.

To Gabbi – Thank you for keeping my spirits up and for coming to visit me in the city. We might have to commemorate this event with a death walk through DC.

DEDICATION

To Mom, Dad, and Gabbi. The best team of cheerleaders a graduate student could ask for.

CHAPTER 1: Introduction

Injection drug use, HIV, and HCV

Injection drug use continues to be an important public health problem in the United States. According to the National Survey on Drug Use and Health (NSDUH), an estimated 425,000 persons aged 12 years and older used a needle to inject illicit drugs in 2008.[1] People who inject drugs (PWID) are at risk of acquiring and transmitting blood-borne viruses (BBVs) through the use of high-risk injection behaviors. They may use contaminated injection equipment obtained from unsafe sources or share syringes with serodiscordant PWID, facilitating the spread of infections like HIV, hepatitis B virus (HBV), and hepatitis C virus (HCV).[2,3] PWID may also reuse their own syringes, increasing their risk of endocarditis, abscesses, and cellulitis.[4,5]

Because of the seriousness of their sequelae, HIV and HCV are of special concern among the health risks associated with injection drug use. In the United States, an estimated 8% of new HIV infections can be attributed to injection drug use, while an additional 3% are associated with both injection drug use and male-to-male sexual contact.[6] Approximately 9-12% of PWID in the United States are HIV-positive.[7] While HIV incidence among PWID has decreased dramatically since the early 1990s,[8,9] drug injection continues to be the main driver of HCV transmission in the United States.[10] In 2013, 62% of acute HCV cases for which risk factors were reported were due to illicit drug injection.[10] A systematic review on the global epidemiology of HCV estimated that 70-77% of PWID in the United States are HCV antibody positive.[11] Additional studies suggest a high incidence of HCV shortly after the initiation of injection drug use. Hagan and colleagues estimated that HCV incidence was 27.6% (16.9%-41.7%) among PWID during their first year of drug injection.[12]

New York City represents an important microcosm of the drug injecting population in the United States. By the late 1980s, the city had become the epicenter of the nation's injection drug use and HIV/AIDS epidemics.[13] Today, it is still home to the largest drug injecting population in the country, with an estimated 104,000 PWID residing in the New York, NY metropolitan statistical area.[14] Extensive harm reduction efforts designed to increase access to sterile syringes among PWID have brought about large declines in the proportion of new HIV/AIDS diagnoses attributable to injection drug use.[9] In the early 1990s, as many as 50% of new HIV/AIDS cases occurred among PWID,[15] while that proportion was just

4.4% in 2012.[16] However, HCV remains common among PWID in New York City. A population-based serosurvey conducted in 2004 found that 64.5% of PWID were HCV antibody positive.[17]

Syringe exchange programs

While drug treatment is recommended for all PWID, many members of this population face barriers to seeking treatment, and therefore, continue to inject. As a result, the public health community has adopted a harm reduction approach to address the negative consequences of injection drug use. Federal agencies recommend that PWID use a new, sterile syringe for each injection to limit the risk of BBVs and other infections brought about by high-risk injection behaviors, including the use of unsafe syringe sources, syringe sharing, and syringe reuse.[2,18] Syringe exchange programs (SEPs) have been opened in cities across the United States to increase access to sterile syringes among PWID and to remove used syringes from circulation. Many SEPs offer a variety of additional services as well, including referrals to drug treatment, HIV testing, TB screening, on-site medical care, and access to food and clothing.[19,20] As of July 2013, there were more than 200 SEPs operating in 166 cities across the United States.[21] Fourteen of these programs are located in New York City, where they operate more than 45 fixed sites and mobile outreach teams.[22]

Since the first SEP opened in Amsterdam in 1984, these programs have been evaluated extensively in the literature.[23-25] Numerous studies suggest that participation in SEPs is associated with reduced syringe sharing among PWID.[23-25] A recent "review of reviews" on the provision of sterile injection equipment to PWID found that 39 of 43 studies on SEP effectiveness detected significant reductions in injection risk behavior among PWID who had access to their services.[25] Additional studies have linked SEP use to decreases in HIV incidence.[9,26] Although the evidence linking SEPs to reductions in HCV incidence is more tenuous, several reports have documented inverse associations between SEP use and HCV infection as well.[27-30]

Despite the evidence supporting the effectiveness of SEPs, their operation remains controversial in the United States. Law enforcement agencies and some community members view the distribution of syringes as enabling drug use, which is commonly framed as an illegal and morally unacceptable behavior.[13] The negative connotation associated with drug use, and drug injection in particular, has

created significant barriers to SEP use among PWID. Injectors often cite police harassment as a barrier to obtaining syringes from SEPs, and, with the exception of a brief period between 2009 and 2011, Congress has prohibited the federal funding of these programs since 1988.[31-33] Community opposition and insufficient financial support have limited the number of SEPs operating in the United States and the services they provide.[13] As a result, many have restricted hours of operation and may be located too far from the residences of PWID to provide adequate syringe coverage.

Non-prescription syringes sales from pharmacies

Given the limitations of SEPs to meet the injection equipment needs of PWID and the importance of preventing BBVs, several US states have legalized the sale of syringes from pharmacies without a prescription. Pharmacies are often open for longer hours than SEPs and may be more conveniently located for PWID to access. As a result, they serve as an important alternative syringe source for PWID and may reach populations of injectors who do not use SEPs.[34] Because the legalization of syringe sales is relatively new, few studies have been published on its effectiveness. At least three studies conducted in the United States have documented reductions in syringe sharing after the initiation of pharmacy syringe sales;[35-37] however, little to no evidence exists with regard to the role that pharmacy-acquired syringes may play in the prevention of BBVs.[25]

In New York State, non-prescription pharmacy syringe sales became legal with the implementation of the Expanded Syringe Access Program (ESAP) in January 2001.[38,39] Under the ESAP law, pharmacists, medical providers, and health care facilities that register with the New York State Department of Health are permitted to sell or furnish up to 10 syringes at a time to persons 18 years of age or older. Within a year of the program's initiation, up to 89% of pharmacies in each of New York City's boroughs were selling syringes under the law.[40] An evaluation of ESAP conducted in Harlem and the Bronx found that the use of syringes known to have been used by another injector, commonly referred to as *receptive syringe sharing*, decreased significantly among PWID after the start of the program, from 13.4% at the beginning of 2001 to 3.6% in mid-2003.[37] Furthermore, logistic regression models from this study showed that time since ESAP implementation and having obtained the last used syringe through ESAP were associated with decreased receptive syringe sharing at the last injection.

The problem: high-risk injection behavior

Despite the availability of sterile syringes from SEPs and pharmacies in NYC and many other parts of the country, PWID continue to face barriers to accessing sterile syringes from safe, legal sources. These barriers include restricted hours of SEP operation, distance to SEPs, and police harassment at points of sterile syringe access. As a result of these and other barriers that have yet to be identified, PWID engage in high-risk injection behaviors that facilitate the transmission of BBVs (Figure 1.1). For the purposes of this dissertation, the term *high-risk injection behavior* will refer to injection risk behaviors that reflect low sterile syringe access among PWID – for example, the acquisition of syringes from unsafe sources, syringe sharing, syringe reuse, and unsterile syringe use. As mentioned previously, PWID continue to practice each of these behaviors despite structural interventions to increase sterile syringe access in this population.

A report summarizing data collected from a sample of PWID between 2006 and 2008 as part of the NSDUH illustrates the extent of this problem.[1] When PWID were asked where they acquired the syringe used at the last injection, more than 65% reported using a safe syringe source: 52.8% had purchased the syringe from a pharmacy, while 12.4% had used a SEP. However, the remaining 34% of respondents reported potentially unsafe syringe sources: 11.8% bought the syringe on the street, 0.5% used a syringe from a shooting gallery, and 21.9% acquired the syringe from "other" sources. A shooting gallery is a location, often an abandoned building or private residence, where PWID can rent, borrow, or purchase syringes for the purpose of injecting drugs. Shooting galleries and street syringe buys are considered unsafe because the injection equipment available in these venues may have previously been used by other PWID. "Other" syringe sources may also be unsafe because they include both potentially safe and unsafe syringe sources. Potentially safe syringe sources in the "other" category include people who distribute syringes from SEPs or pharmacies, health care providers, and diabetic friends or relatives. Conversely, examples of potentially unsafe syringe sources in the "other" category include friends or relatives who either share their used syringes or acquire their syringes from an unspecified source.

In addition to the use of unsafe syringe sources, receptive syringe sharing, syringe reuse, and unsterile syringe use continue to be problematic. PWID who face barriers accessing sterile syringes from

safe sources may accept syringes that have been used by other PWID or reuse syringes they have already used in the past. According to the NSDUH report described above, 51.0% of PWID reused a needle they had used before during the last injection episode, while 13.0% used a needle that they knew or suspected someone else had used before them.[1]

The risk environment

In an effort to curb BBV transmission among PWID, investigators have attempted to identify the determinants of high-risk injection behavior. Although these behaviors are likely influenced by factors operating at the level of the individual, empiric literature is emerging to suggest that they are also influenced by the environment in which they occur.[41-49] Several authors have written conceptual articles describing how contextual determinants influence BBV risk,[50,51] but the paradigm most often cited is that proposed by Rhodes and colleagues in their writings on the *risk environment*.[52-54] The risk environment is comprised of factors exogenous to the individual – the space in which physical, social, political, and economic influences interact to shape risk behavior and BBV transmission.[53] In this paradigm, risk factors are conceptualized as operating on multiple levels of influence, ranging from micro- to macro-scale. A micro-level influence may function within interpersonal relationships among PWID, while a macro-level influence affects large groups of PWID simultaneously. Examples of factors in the risk environment that may affect syringe access behavior include neighborhood socioeconomic disadvantage and the social discomfort experienced by PWID in pharmacies and SEPs. These examples are discussed in detail below.

Neighborhood socioeconomic disadvantage and high-risk injection behavior

Neighborhood socioeconomic disadvantage has been linked to a variety of health outcomes and behaviors.[55] Examples include all-cause mortality, low birth weight, systolic blood pressure, and smoking.[55] Although numerous studies have demonstrated the importance of this construct in shaping health outcomes, its influence on risky injection practices has yet to be thoroughly explored.

Existing evidence suggests a number of pathways through which neighborhood disadvantage may increase high-risk injection behavior (Figure 1.1). For example, disadvantaged neighborhoods may

have larger populations of PWID, which may lead injectors to form larger, denser injection networks. Both network size and network density have been shown to be associated with syringe sharing,[56] potentially increasing the likelihood of high-risk injection behavior in poor neighborhoods. Disadvantaged neighborhoods may also have a greater availability of syringes from unsafe sources, such as syringe dealers and public spaces dedicated to injection drug use. PWID in these neighborhoods may, therefore, be more likely to use unsafe syringe sources in comparison to those in less disadvantaged neighborhoods. A third pathway through which neighborhood disadvantage may influence high-risk injection behavior is through neighborhood disorder. Neighborhood disorder can be defined as a series of physical and social characteristics that are indicative of neighborhood decay. Examples include graffiti, vacant housing, litter on the street, loitering teens, and the prevalence of burglary, drug selling, and assault. Neighborhoods with poor socioeconomic indicators may exhibit higher levels of disorder, which may impose psychological distress on PWID.[57-59] This psychological distress may lead PWID to engage in riskier injection practices. Latkin and colleagues found evidence to support this hypothesis among a sample of 701 PWID in Baltimore, Maryland.[41] Structural equation models suggested that psychological distress was higher among PWID in more disordered neighborhoods, which led to greater sharing and use of unsterile injection equipment.

Although the relation between neighborhood disadvantage and high-risk injection behavior has yet to be thoroughly investigated, at least one US study has considered the influence of neighborhood-level socioeconomic characteristics on receptive syringe sharing. In a sample of 4,956 PWID recruited in the San Francisco Bay area, Bluthenthal et al. found no association between census tract-level socioeconomic indicators and receptive syringe sharing in the past six months.[42] While the authors of this study concluded that measures of neighborhood socioeconomic context may be poor predictors of risk behavior among PWID, they also acknowledged that the results of their analyses may have been biased by random measurement error. For approximately one-third of the study sample, there was some ambiguity in assigning participants to their corresponding census tracts. As a result, non-differential misclassification may have underestimated relations between neighborhood socioeconomic indicators and receptive syringe sharing, potentially rendering null findings despite the existence of underlying associations.

The study of area-level and spatial predictors of injection drug use behavior is an emerging field, and this literature has yet to be reviewed. Although neighborhood socioeconomic context has been linked to a variety of health conditions, the influence of this construct on high-risk injection behavior remains unknown. With sterile syringe equipment now available to PWID through both SEPs and pharmacies in several US states, additional research is needed to evaluate how neighborhood disadvantage may influence risky injection behaviors in the setting of increased syringe availability. Clarifying this relation may lead to more effective targeting of harm reduction interventions geared toward the prevention of BBVs among PWID.

Neighborhood socioeconomic disadvantage, syringe exchange program accessibility, drug-related police activity, and high-risk injection behavior

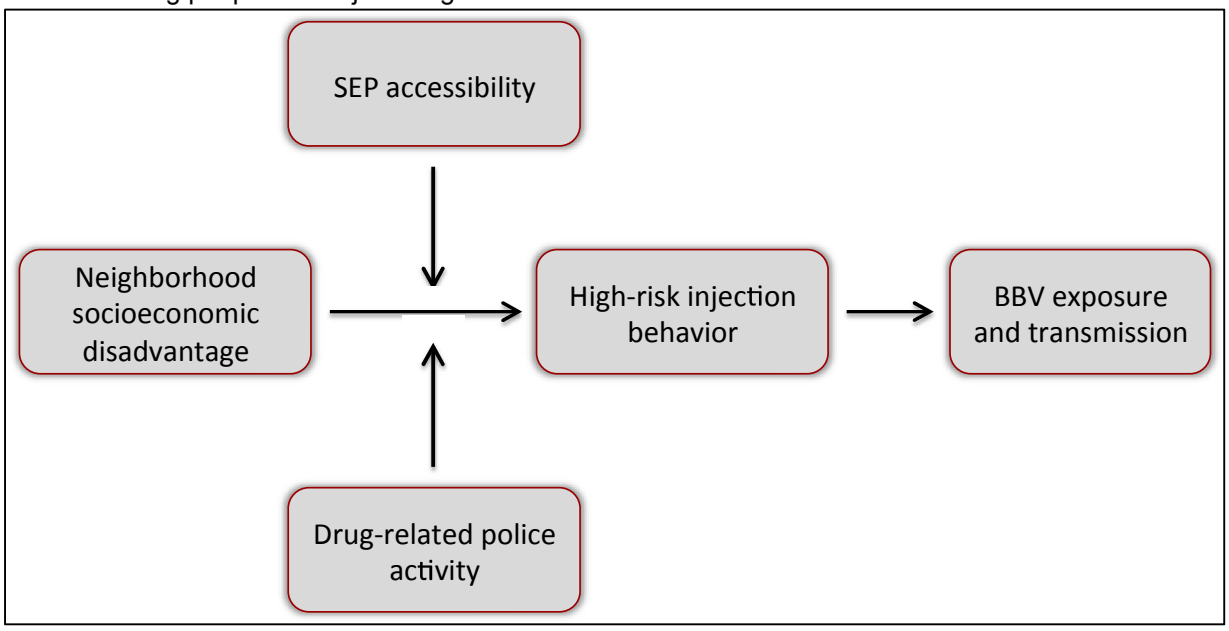
As discussed above, the risk environment paradigm emphasizes not only the influence of contextual factors on BBV transmission, but also the interplay of these factors in shaping outcomes among PWID. Therefore, further investigation of the relation between neighborhood disadvantage and high-risk injection behavior should study, not only the association between these constructs, but also how these relations are modified by other factors in the risk environment. A review of current evidence reveals two potential modifiers of relations between neighborhood disadvantage and high-risk injection behavior: SEP accessibility and drug-related police activity (Figure 1.1).

Extensive research has shown that SEP participation is inversely associated with high-risk injection behavior; however, further studies suggest that SEP accessibility is inversely associated with this outcome as well.[44-46,60] Among a sample of 805 PWID in New York City, Rockwell and colleagues found that participants residing within a 10-minute walk of a SEP were more likely to report SEP use and less likely to report receptive syringe sharing than participants who lived farther away.[44] Similarly, among a sample of 2576 PWID in Glasgow, Scotland, participants who resided within one mile of a SEP were less likely to report receptive syringe sharing in the six months prior to interview.[45]

While SEP accessibility appears to decrease the likelihood of high-risk injection behavior, drug-related police activity has been established as a barrier to syringe access. Qualitative studies conducted among samples of PWID around the world reveal a widespread fear of police encounters.[61-66] Depending

on local drug laws, PWID stopped by police may be subjected to violence, have their syringes confiscated, or be arrested for possession of drugs and injection paraphernalia. Such negative experiences with law enforcement may discourage PWID from carrying sterile syringes and from accessing syringes from pharmacies and SEPs.[66-69] In a study conducted in New York City, Beletsky and colleagues found that PWID who reported police stops were less likely to use SEPs consistently.[70] Similarly, studies in Oakland, California; Philadelphia, Pennsylvania; Vancouver, Canada; and a suburb of Melbourne, Australia found that police crackdowns were linked to decreased SEP attendance and unsafe injecting practices.[69,71-73] PWID who refrain from carrying sterile syringes, avoid safe syringe sources, or have syringes confiscated by police may be without sterile injecting equipment when the opportunity to inject arises. Consequently, they may be more likely to engage in high-risk injection behaviors, including the use of unsafe syringe sources, receptive syringe sharing, and syringe reuse.[66,67,72] Two studies conducted in California provide evidence to support this hypothesis. In both analyses, concern about being arrested while carrying drug paraphernalia was positively associated with sharing syringes and injection supplies.[74,75]

Figure 1.1. Model of the influence of neighborhood socioeconomic disadvantage on high-risk injection behavior among people who inject drugs



Social discomfort and high-risk injection behavior

In addition to neighborhood disadvantage, many social elements of the risk environment remain understudied as determinants of high-risk injection behavior. One example is the social discomfort experienced by PWID when accessing syringes from pharmacies and SEPs (Figure 1.2). Numerous qualitative studies have shown that PWID feel uncomfortable entering pharmacies to purchase syringes, even in areas where such sales have been legalized.[61,62,76-78] Many fear being labeled as "injection drug users" by pharmacy staff and suffering poor treatment as a result.[61,62,76-80] One woman described her experience with pharmacy staff as follows: "…they don't smile at you or nothing, know what I mean,…if you're in there with other people and that, customers, you don't know what they are going to say and you feel uncomfortable."[78] Experiences like these have led PWID to cite unfriendly attitudes and judgmental treatment by pharmacy staff as obstacles to pharmacy syringe purchases.[62,77,81] Pharmacists may refuse to sell syringes to PWID or question them about the intended use of syringes.[61,76,79,82] In addition, PWID may be reluctant to ask pharmacists for syringes out of fear that pharmacy staff and/or other shoppers may become aware of their drug use, and inform other members of the community.[76,78,81]

Although some injectors are hesitant to enter SEPs for fear of publicly identifying themselves as PWID,[65,78,83] many seem to feel more comfortable entering SEPs than pharmacies.[61,76,84] In qualitative interviews, some refer to SEPs as safe havens in which they can acquire syringes and access needed services in a nonjudgmental environment.[76,84] In contrast to pharmacy staff, SEP staff have been described as helpful, understanding, and supportive.[64,76,78,83,84]

Several investigators have attributed the social discomfort experienced by PWID in pharmacies and SEPs to the stigma associated with injection drug use.[76-78] According to Goffman, stigma is "an attribute that is deeply discrediting" and one that reduces the individual "from a whole and usual person to a tainted discounted one."[85] Observers have described at least three types of stigma that stigmatized individuals may encounter – enacted stigma, internalized stigma, and perceived stigma. Enacted stigma is the extent to which individuals experience discrimination from others in reaction to their stigmatized attribute.[86] Internalized stigma is the extent to which individuals adopt negative beliefs about their stigmatized attribute and apply them to the self.[87] Perceived stigma is the extent to which individuals expect to experience discrimination from others in reaction to their stigmatized attribute.[88] Negative

attitudes toward drug use and drug injection are pervasive in today's society, and as a result, PWID are highly stigmatized. The social discomfort that PWID describe on entering pharmacies and SEPs may fall under the category of perceived injection drug use stigma.

Little quantitative research has been conducted on the effects of injection drug use stigma; however, one report has documented a positive association between drug use stigma and syringe sharing. Among a sample of PWID recruited in Chennai, India, Latkin et al. found that perceived drug use stigma was positively associated with syringe sharing.[89] The mechanism through which drug use stigma may influence syringe sharing was not investigated in this study, but more recent findings suggest that social discomfort may mediate these associations by acting as a barrier to sterile syringe access. Among a sample of PWID in New York City, Rivera et al. found that higher levels of injection drug use stigma were associated with not accessing sterile syringes from SEPs or pharmacies in the past three months.[90] Additional research indicates that stigma is a powerful barrier to accessing health services in the context of several other health conditions as well, including HIV,[91,92] depression,[93] and obesity.[94]

Taken together, this evidence suggests that the social discomfort experienced by PWID as a result of perceived stigma experienced in pharmacies and SEPs may shape high-risk injection behavior (Figure 1.2). PWID who feel uncomfortable acquiring syringes from pharmacies and SEPs may visit these venues less frequently and be more likely to obtain syringes from unsafe sources. In addition, they may be less likely to have sterile syringes during injection episodes, and therefore, engage in higher rates of syringe sharing and syringe reuse. To date, there have been no epidemiologic studies, of which I am aware, that have examined the influence of social discomfort on high-risk injection behaviors. The qualitative and quantitative findings discussed above suggest that this may be a critical research gap.

Social discomfort, neighborhood socioeconomic disadvantage, and high-risk injection behavior

Recalling the risk environment paradigm once more, it is possible that relations between social discomfort and high-risk injection behavior are modified by other elements of the local area context. Neighborhood socioeconomic disadvantage, for example, may determine the extent to which high-risk injection behavior is shaped by social discomfort (Figure 1.2); however, the influence that this potential modifier may exert on relations between social discomfort and high-risk injection behavior is unclear.

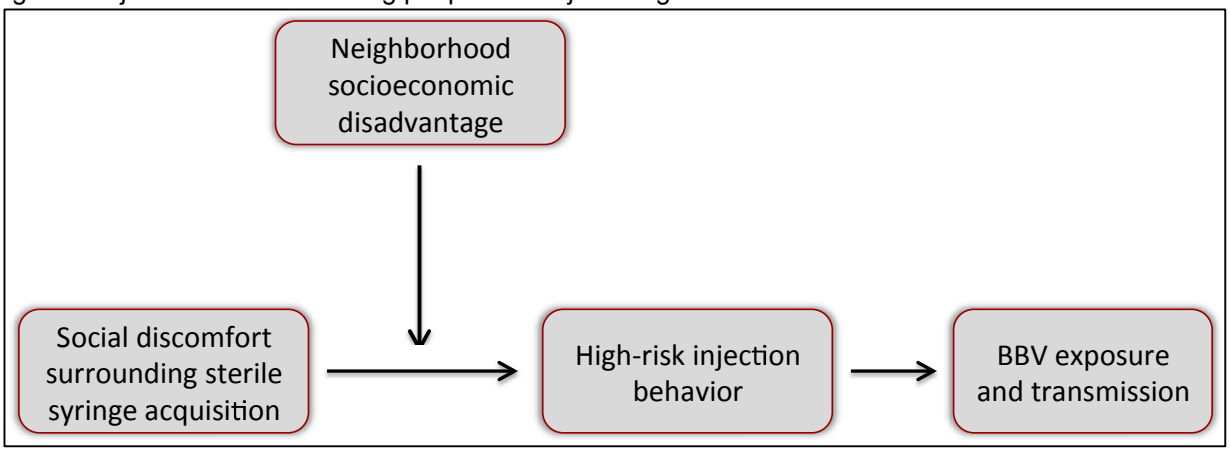
Disadvantaged neighborhoods are typically characterized by a number of negative characteristics that increase the likelihood of risky injection behavior – a greater availability of syringes from unsafe sources, larger networks of PWID, and increased drug-related police activity. Together, these attributes may enhance the negative influence of social discomfort. PWID in poor areas may be more easily deterred from pharmacies and SEPs by feelings of discomfort than those in less disadvantaged areas due to the higher availability of injection equipment through alternative means – not only from unsafe syringe sources, but also from other injectors. Fear of being stopped and hassled by police while carrying syringes may also serve to discourage PWID from overcoming social discomfort to utilize safe syringe sources.

Alternatively, neighborhood disadvantage may buffer associations between social discomfort and high-risk injection behavior. Although poor neighborhoods are generally deprived of resources, they have been targeted with HIV prevention services that may not be found in advantaged areas. SEPs, for example, are likely more prevalent in poor neighborhoods. As a result, relations between social discomfort and high-risk injection behavior may be may be weaker in these neighborhoods due to the higher availability of safe syringe sources for PWID. In addition, SEPs promote harm reduction not only through the distribution of sterile injection equipment, but also by educating participants on the risks associated with unsafe injection. This “risk awareness” may circulate through injection networks whose members reside close to SEPs, potentially making these PWID less likely to abandon safe syringe sources due to feelings of social discomfort.

A second pathway through which neighborhood disadvantage may buffer the influence of social discomfort involves psychosocial factors. PWID may possess a number of stigmatized characteristics that render them socially isolated from their communities. Examples include their status as PWID, membership in ethnic/racial minority groups, low SES, homelessness, and a history of incarceration. Because these characteristics are more common in disadvantaged neighborhoods than in less disadvantaged ones, they may also be less stigmatized. As a result, PWID in disadvantaged neighborhoods may have more social ties and social support than their counterparts in less disadvantaged areas. Consequently, they may also be less easily deterred from utilizing safe syringe sources by feelings of social discomfort. Evidence to support this hypothesis arises from studies linking

social support to increased health service utilization. In a study conducted among HIV-positive, black PWID in Baltimore, Maryland, Knowlton and colleagues reported a positive association between social support and medical service use.[95] Additional studies have found that social support is linked to participation in drug treatment and mental health service utilization among drug users.[96,97]

Figure 1.2. Model of the influence of social discomfort surrounding the acquisition of sterile syringes on high-risk injection behavior among people who inject drugs



Specific aims

Considering the evidence presented above, this dissertation will address three specific aims: 1) To systematically review the literature regarding the influence of neighborhood context on injection drug use behavior, 2) To determine whether neighborhood socioeconomic disadvantage is associated with high-risk injection behavior among PWID, and whether this association is modified by SEP accessibility and drug-related police activity, and 3) To determine whether social discomfort surrounding the acquisition of syringes from pharmacies and SEPs is associated with high-risk injection behavior, and whether this association is modified by neighborhood socioeconomic disadvantage.

CHAPTER 2: The influence of neighborhood context on injection drug use behavior: A systematic review

INTRODUCTION

Injection drug use continues to be an important public health problem worldwide. Not only does this behavior increase the risk of soft-tissue infections such as abscesses and cellulitis, but it also facilitates the transmission of bloodborne viruses (BBVs), including human immunodeficiency virus (HIV), hepatitis C virus (HCV), and hepatitis B virus (HBV).[2-5] In the United States, an estimated 8% of new HIV infections were attributable to injection drug use in 2010, while a further 3% occurred among individuals who engaged in both injection drug use and male-to-male sexual contact.[6] Use of injection drugs was also reported by 62% of acute HCV patients and 23% of acute HBV patients who provided information on their drug use history in 2013.[10]

In an effort to curb the use of injection drugs and associated practices that drive the transmission of BBVs, investigators have attempted to identify determinants of injection drug use behavior. Much of this work has focused on factors operating at the individual level; however, studies have shown that interventions designed to change individual-level behavior among PWID are insufficient to eliminate their risk of BBVs.[98,99] A review of HIV prevention interventions for PWID found that these interventions may only reduce the risk of unsafe injection practices by 25%.[98] As a result, more recent research has begun to investigate the influence of forces beyond the level of the individual on injection drug use behavior. Numerous conceptual articles have discussed how factors operating in the social and structural environments may shape risk behavior among PWID.[50,51,53] Rhodes and colleagues, for example, have posited that BBV transmission and injection risk behavior are determined, in large part, by the *risk environment*, or the space in which all factors exogenous to the individual interact to influence outcomes.[53] According to this paradigm, BBV risk and injection practices among PWID are shaped by factors in the physical, social, political, and economic environments operating at micro, meso, and macro levels of influence.

One element of the risk environment that has received increased attention in recent years is the neighborhood context. The emergence of methods well-suited to the study of area-level phenomena, such as multilevel modeling and geographic information systems, has stimulated interest in the investigation of neighborhood health effects. Neighborhood characteristics, such as socioeconomic disadvantage and social cohesion, have been identified as determinants of a variety of health conditions,

ranging from low birth weight to hypertension.[55,100] More recently, studies have begun to examine elements of the neighborhood and spatial context as potential determinants of injection drug use behavior. Existing research suggests that these local area characteristics may influence injection drug use behavior through several mechanisms, including sterile syringe availability and psychological distress.[41,47]

Here, we undertake a systematic review of the literature regarding the influence of neighborhood context on injection drug use and associated behaviors. We catalogue neighborhood and spatial characteristics that have been studied as potential correlates of injection drug use behavior and summarize these studies' findings to identify elements of the local area context likely to shape BBV risk among PWID. Finally, we discuss limitations of the extant literature and identify avenues for future research.

METHODS

We conducted a qualitative systematic review of the literature regarding the influence of neighborhood context on injection drug use behavior. Quantitative meta-analyses were not possible due to the small number of studies identified pertaining to each neighborhood characteristic.

Search strategy

Our literature search was conducted using the PubMed, PsycInfo, and Web of Science databases. Searches were limited to English-language journal articles published from 1995 to the date on which all searches were performed – December 12, 2014. Each database was queried with two combinations of keywords: (i) one pertaining to neighborhood context (e.g. 'Community', 'Neighborhood', 'Neighbourhood', 'Spatial', 'Area', 'Environment*', 'Place', 'Geographic', 'Context'), (ii) and a second pertaining to injection drug use behavior (e.g. 'Intravenous drug', 'Injecting drug', 'Injection drug', 'Inject drugs', 'Injectors'). The results of these searches were combined with the AND operator to generate a list of candidate articles related to the review topic. For databases with controlled vocabularies (PubMed, PsycInfo), a second search was conducted using only controlled vocabulary terms. Reference lists of

selected articles were hand-searched for additional studies. A detailed description of the search strategy is provided in Appendix B.

Study selection

Studies were chosen for inclusion in the review on the basis of three criteria. First, selected studies must have investigated at least one individual-level outcome related to injection drug use behavior. For the purposes of this review, the term *injection drug use behavior* refers to any behavior surrounding the use of injection drugs, such as injection frequency, injection cessation, syringe sharing, and the use of unsafe syringe sources. Second, studies must have either assessed associations between neighborhood characteristics and injection drug use behavior, or investigated neighborhood characteristics as modifiers of the influence of other factors on injection drug use behavior. Here, we define *neighborhood characteristics* as those measuring features of the physical, social, political, and economic environments on an infra-city scale. These characteristics are often measured using one of four basic approaches: (i) a collective geographic approach, in which geographic space is divided into units and characteristics of the individuals within each unit are aggregated to create neighborhood-level measures, (ii) a spatial approach, in which the distance between a participant's location (often the location of residence) and a second location are calculated to measure the geographic proximity of sites of interest, (iii) an observational approach, in which groups of researchers either directly observe or view video footage of neighborhoods to rate their characteristics, and (iv) a self-report approach, in which participants are asked to respond to items pertaining to attributes of their neighborhoods or their residential proximity to locations of interest.[101] Studies were included regardless of the method used to measure neighborhood characteristics. Third, analyses must have adjusted for potential confounders.

Exclusion criteria were chosen to restrict the scope of the review to studies reporting generalizable results related to the influence of the local-area environment on individual-level outcomes among PWID. Studies were excluded if they compared injection drug use behavior among PWID from only two neighborhoods, or if they assessed geographic variation in behavior without incorporating neighborhood characteristics. Ethnographic and ecologic analyses were also excluded.

RESULTS

Systematic literature search

Our search yielded 4,578 articles, of which 65 were chosen for full-text examination after screening by title and abstract. Of these 65 articles, 23 met our inclusion criteria. One study was removed due to the use of poorly defined outcomes in the analysis, leaving 22 studies for inclusion in the review. A hand search of the reference lists of these articles yielded no additional studies related to the review topic. Figure 2.1 depicts the iterative process through which studies were identified.

Description of included studies

All of the studies selected for review used data from the United States or Canada, with the exception of one study conducted in Glasgow, Scotland. Eight studies used data from Baltimore, Maryland; five used data from New York, New York; three used data from San Francisco, California; and two used data from Montreal, Canada. Seventeen studies utilized a cross-sectional study design, while the remaining five were longitudinal. Nearly all of the studies concentrated on the influence of the residential neighborhood on injection drug use behavior, although two studies used the location of recruitment as the focus of the analysis. Analyses were conducted using a diverse array of methods, including logistic regression, binomial regression, generalized estimating equations, multilevel modeling, and structural equation modeling. Approximately half of the studies utilized an analytic approach that accounted for the clustering of participants within neighborhoods. With the exception of four studies, all analyses were also adjusted for at least one individual-level socioeconomic indicator – either income, educational attainment, employment status, or receipt of government assistance.

Several injection drug use behaviors were examined. These included behaviors pertaining directly to the use of injection drugs, such as injection frequency and injection cessation, and behaviors associated with BBV transmission, such as injection equipment sharing. Additional studies investigated behaviors surrounding the acquisition of sterile syringes from safe syringe sources. All outcomes were ascertained via self-report. Characteristics of the neighborhood context assessed in the studies could be grouped into two broad categories, which are discussed in the sections below: neighborhood

socioeconomic disadvantage and sterile syringe access. Most studies utilized either a collective geographic approach or a spatial approach to measure features of the neighborhood context, although a small number of studies relied on participants' self-reports. When a collective geographic approach was used, administratively defined units of geography were most commonly utilized as neighborhood proxies. These ranged in size from census tracts to neighborhood statistical areas and health districts. However, three studies approximated participants' local area by creating buffers centered on the location of residence. The results of all studies are described in Table 2.1. Study findings are organized by neighborhood characteristic and injection drug use behavior in Table 2.2.

Neighborhood socioeconomic disadvantage

Neighborhood socioeconomic disadvantage and injection drug use among PWID

Disadvantaged neighborhoods possess a number of characteristics that are hypothesized to increase injection drug use. Abandoned buildings and substandard housing, for example, may serve as locations in which injection drugs are sold and consumed. Unemployment may create populations of individuals with little time structure and low self-esteem, potentially increasing their risk of drug use and drug injection. Simultaneously, violent crime may increase levels of psychological distress, predisposing community members to the use of injection drugs.[102]

Although three studies were conducted on the relation between neighborhood socioeconomic disadvantage and injection drug use, all of these studies were conducted in Baltimore, Maryland using participants from the AIDS Linked to the Intravenous Experience (ALIVE) cohort.[103-105] In each analysis, measures of neighborhood disadvantage were linked to increased injection drug use. Nandi and colleagues analyzed the relation between neighborhood poverty and injection drug use among a sample of 1875 PWID from the ALIVE cohort.[103] When traditional regression techniques were applied, no association was detected. However, when confounding was controlled using inverse probability weights, the proportion of census tract residents living in poverty was positively associated with having injected drugs in the past six months. In a similar analysis, Genberg and colleagues examined the relation between neighborhood deprivation and long-term injection cessation.[104] In this study, neighborhood deprivation was measured using an index of eight census tract-level indicators, and long-term injection

cessation was defined as abstinence from injection drug use for three years. Among a sample of 1697 PWID from the ALIVE cohort, these authors found that living in the most deprived neighborhoods was inversely associated with long-term injection cessation. In addition, relocation from the most deprived to a less deprived neighborhood was positively associated with injection cessation. Linton and colleagues reported similar results in their examination of the relation between neighborhood residential rehabilitation and injection drug use, using a sample of 1818 PWID from the ALIVE cohort. In this analysis, neighborhood residential rehabilitation was defined as the proportion of residential properties in participants' neighborhood statistical area in which investment in interior or exterior maintenance exceeded $5,000 USD in a given year. In comparison to neighborhoods with the lowest levels of rehabilitation, residence in neighborhoods with moderate and high levels of rehabilitation was associated with decreased injection drug use in the past six months. Relocation from neighborhoods with low rehabilitation to moderate or high rehabilitation was also inversely associated with injection drug use.

Two additional studies on neighborhood social disorder provide further support for the association between neighborhood disadvantage and injection drug use. These analyses were conducted in Baltimore, Maryland using data from the SHIELD study and relied on participants' self-reports to characterize their neighborhoods.[41,106] Among a sample of 200 heroin injectors, Sherman and colleagues found that perceived severity of drug selling in the neighborhood was not associated with injection drug use in the past six months.[106] However, participants who reported traveling within their neighborhoods of residence to buy drugs were more likely to report injection drug use in the past six months than those who did not. Latkin and colleagues used similar methods to study the influence of neighborhood social disorder on injection frequency among a sample of 701 PWID.[41] In this study, participants were asked to indicate "how big of a problem" each of the following was in their neighborhoods: vandalism, vacant housing, litter or trash on the street, loitering teens, burglary, drug selling, and robbery or assault. They were also asked to complete a depression scale and to indicate how often they had used heroin, cocaine, and speedball in the past six months. These items were subsequently used in structural equation models as manifest variables measuring neighborhood social disorder, psychological distress, and injection frequency, respectively. Analyses indicated that neighborhood social disorder led to greater injection frequency by increasing injectors' psychological distress.

The consistency of results linking neighborhood socioeconomic disadvantage and neighborhood social disorder to injection drug use may be explained, in large part, by the fact that all of these studies were conducted in the same city using similar study populations. However, these results are made more robust by the fact that significant associations were detected in all analyses despite the wide variety of measures used. Neighborhood socioeconomic disadvantage was operationalized as census tract-level poverty, an index of eight census tract-level indicators, and as residential rehabilitation, which was measured at the level of the neighborhood statistical area. Neighborhood social disorder was measured through participants' self-reports, but still yielded results consistent with those generated using administrative data. Furthermore, the studies on neighborhood socioeconomic disadvantage were prospective, providing additional evidence of a causal relation between disadvantage and injection drug use. The detection of an inverse association between moving to a wealthier neighborhood and the use of injection drugs is especially compelling. Together, this evidence suggests that neighborhood disadvantage may increase injection drug use, although additional studies are urgently needed in other geographic contexts.

Neighborhood socioeconomic disadvantage and injection risk behavior

Neighborhood socioeconomic disadvantage has been hypothesized to increase, not only injection drug use, but also injection risk behaviors that facilitate the transmission of BBVs. Many of the same social and structural pathways that have been theorized to fuel injection drug use may mediate relations with injection risk behavior as well. For example, the prevalence of abandoned buildings may foster the development of drug markets from which PWID can obtain contaminated injection equipment. In addition, violent crime may increase psychological distress, making PWID more likely to engage in risky injection practices, such as syringe sharing.[41]

Two studies examined associations between measures of neighborhood socioeconomic disadvantage and injection risk behavior.[41-43] The results of these analyses were mixed. Among a sample of 4,589 PWID in the San Francisco Bay area, Bluthenthal and colleagues found that percent of households on public assistance, percent male unemployment, median household income, and an index of neighborhood deprivation (all of which were measured at the census tract level) were not associated

with either receptive syringe sharing or distributive syringe sharing in the past six months.[42] However, the proportion of African American residents in the census tract was associated with a decreased likelihood of both receptive syringe sharing and distributive syringe sharing. A similar study conducted by Genereux and colleagues in Montreal, Canada evaluated the influence of neighborhood socioeconomic disadvantage and low neighborhood educational attainment on high-risk injection behavior among a sample of 219 inner-city PWID.[43] Analyses revealed that neighborhood disadvantage was positively associated with high-risk injection behavior, while low neighborhood educational attainment was inversely associated with this outcome. Neither neighborhood disadvantage nor neighborhood educational attainment were associated with high-risk injection behavior among 249 PWID in boroughs outside the inner-city area.

In addition to the two studies investigating associations between measures of neighborhood socioeconomic disadvantage and injection risk behavior, the study by Latkin and colleagues described in the last section included analyses on the relation between perceived neighborhood social disorder and injection equipment sharing.[41] Structural equation models suggested that psychological distress was greater in more disordered neighborhoods and that distress led to more frequent injection equipment sharing.

The dearth of studies and inconsistency of results pertaining to links between neighborhood disadvantage and injection risk behavior prevent us from drawing conclusions with respect to the existence of this relation. The contradictory nature of the findings may be explained, in part, by the limitations of each analysis. For example, Bluthenthal and colleagues acknowledged some ambiguity in assigning participants to census tracts, which may have biased the results of their analysis toward the null. Conversely, the study by Genereux and colleagues was limited by small sample sizes. Whereas the Bluthenthal study included over 4,500 participants, the Genereux study included only 219. As a result, coefficient estimates from regression models used to measure associations may have been unstable. This would help explain why the association between neighborhood socioeconomic disadvantage and high-risk injection behavior was in the opposite direction of that between low neighborhood educational attainment and the same outcome, despite the fact that these measures of disadvantage were positively

correlated. Overall, additional studies on the influence of neighborhood socioeconomic disadvantage on injection risk behavior are needed to make a determination as to how these constructs may be related.

Sterile syringe access

Spatial access to syringe exchange programs and syringe exchange program utilization

In many cities across the United States and abroad, syringe exchange programs (SEPs) have been implemented to curb the transmission of BBVs among PWID. These programs operate fixed sites and mobile outreach teams from which PWID can access sterile injecting equipment, including syringes, cookers, filters, and water. Extensive research has shown that participation in SEPs decreases both syringe sharing and the incidence of BBVs.[9,25-28,107] As a result, investigators have hypothesized that increased spatial access to these programs increases their utilization and decreases injection risk behavior.

Three studies evaluated the relation between spatial SEP access and SEP utilization, all of which found that living closer to an SEP site was associated with increased SEP use.[44,108,109] Among a sample of 776 PWID in New York City, Rockwell and colleagues found that participants who reported living within a 10-minute walk of a SEP were more likely to obtain needles from SEPs than those who lived farther away.[44] Similarly, in a longitudinal study of all participants in the Baltimore Needle Exchange Program (BNEP) (N=12,388), Gindi and colleagues found that PWID whose zip codes matched those of the BNEP site at which they enrolled were more likely to visit a BNEP site at least once within the next 12 months in comparison to those who reported a different zip code.[108] Finally, among a sample of PWID in Philadelphia, Pennsylvania, Williams and Metzger found that the distance from participants' residences to the nearest SEP site was positively associated with reporting a non-SEP as the usual syringe source.[109] Additional analyses from this study suggest that spatial access to SEPs from non-residential locations may influence SEP utilization as well. These analyses found that Latinos were more likely than whites to report non-SEPs as their usual syringe source as the distance from the nearest SEP to drug buy and injection locations increased.

Although the number of studies conducted on the association between spatial access to SEPs and SEP utilization is small, their results are remarkably consistent. These findings are especially

compelling in light of the fact that these studies were conducted in three different cities using both objective and self-reported measures of SEP proximity. Additional studies are needed to corroborate these results; however, current evidence supports a positive relation between spatial access to SEPs and SEP utilization.

Spatial access to syringe exchange programs and injection risk behavior

Six studies examined the relationship between spatial access to SEPs and injection risk behavior.[44-47,60,110] Of these six studies, only three identified significant associations in the hypothesized direction. Among a sample of 776 PWID in New York City, Rockwell and colleagues found that participants who reported living within a 10-minute walk of an SEP site were less likely to have engaged in receptive syringe sharing at the last injection in comparison to participants who lived farther away.[44] Similarly, among a sample of 2,567 PWID in Glasgow, Scotland, Hutchinson and colleagues found that participants who resided more than one mile from an SEP site were more likely to have injected with a used needle or syringe in the past six months than those who lived in closer proximity.[45] Additional evidence was reported by Cooper and colleagues in a serial cross-sectional analysis of 4,003 PWID entering a detoxification program in New York City between 1995 and 2006.[47] In this analysis, increases in spatial SEP access over time were associated with increased sterile syringe use. Of note, Cooper and colleagues also used this study sample to investigate whether relations between spatial SEP access and injection risk behavior were modified by drug-related police activity. These analyses suggested that the protective effect of spatial SEP access against unsterile syringe use was attenuated by drug-related police activity.[48,49]

The remaining three studies on spatial SEP access and injection risk behavior found that these constructs were not associated. Among a sample of 587 PWID in New York City, Schilling and colleagues found that participants recruited within 10 blocks of an East Harlem SEP site were no less likely than participants recruited farther away to share needles with others, use dirty needles by themselves, or share the same cooker.[46] Bruneau and colleagues also found no association between spatial SEP access and high-risk injection behavior. In this Montreal-based study, SEP access was defined as the distance from participants' postal code of residence to the nearest SEP site.[60] Finally,

among a sample of 989 PWID in San Francisco, California, Martinez and colleagues found no association between SEP accessibility and receptive or distributive syringe sharing in the past six months.[110]

Together, the results of these studies provide reasonably consistent support for an inverse association between spatial SEP access and injection risk behavior. Although half of the studies on this relation reported null results, their findings may be explained by the measures used to operationalize the constructs of interest. For example, the study by Schilling and colleagues relied on the location of recruitment to separate participants into those with high and low spatial SEP access. However, the location of recruitment may not have accurately reflected the geographic space in which participants spent most of their time, and therefore, may have led to their misclassification. Such misclassification may have biased the results of this analysis toward the null. A similar problem may have produced the null findings reported by Martinez and colleagues. In this study, SEP accessibility was defined as whether an SEP site was located within 50 meters of a participant's activity space route (the path connecting the locations where a participant usually slept, hung out, and used drugs in the past 6 months). This measure may have misclassified participants' level of SEP access because SEP sites may have been located in close proximity to spaces frequented by PWID, but not located on their activity space routes. Again, associations may have been biased toward the null. Finally, the null result reported by Bruneau and colleagues may be explained by the injection risk behavior modeled in their analysis. The studies that detected associations in the hypothesized direction used measures of syringe sharing and unsterile syringe use as outcomes. However, Bruneau and colleagues used high-risk injection behavior, which they defined as agreement with any of the following in the past six months: having borrowed a syringe or shared injection material at least five times, having injected with groups of strangers at least five times, or having borrowed a syringe or shared injection material with a known HIV-positive person. It is possible that spatial SEP access may be inversely associated with sharing injection material, but not with injecting among strangers or with sharing injection material with a known HIV-positive person. The inclusion of these elements in the definition of high-risk injection behavior may have caused associations with spatial SEP access to be null.

Spatial access to pharmacies selling syringes over-the-counter and pharmacy syringe purchases

Numerous states have expanded sterile syringe access to PWID, not only through SEPs, but also through the legalization of non-prescription syringe sales from pharmacies. Pharmacies are open for longer hours than SEPs and may be more conveniently located for PWID to access. As a result, they serve as an important alternative syringe source for PWID and may reach populations of injectors who do not use SEPs.[34] Similar to hypotheses regarding the influence of spatial SEP access, spatial access to pharmacies selling syringes over-the-counter has been theorized to increase pharmacy syringe purchases and decrease injection risk behavior.

Only one study examined relations between measures of spatial pharmacy access and pharmacy syringe purchases.[111] Among a sample of 563 PWID in San Francisco, California, Stopka and colleagues tested four measures of pharmacy proximity as potential determinants of pharmacy syringe purchase in the past six months: Euclidian distance from the participant's usual residence to the nearest pharmacy selling syringes over-the-counter, walking distance to the nearest pharmacy, walking time to the nearest pharmacy, and number of pharmacies within a 0.25-mile radius of the participant's usual residence.[111] No associations were found between these measures and the likelihood of pharmacy syringe purchase.

Associations between spatial pharmacy access and injection risk behavior were investigated in four analyses.[47-49,60] The first, conducted by Bruneau and colleagues among PWID in Montreal, Canada, found no association between Euclidean distance from participants' postal code of residence to the nearest pharmacy and high-risk injection behavior.[60] The subsequent three analyses were conducted by Cooper and colleagues using the same sample of New York City-recruited PWID described in the section above.[47-49] In all three analyses, increased spatial access to pharmacies selling syringes over-the-counter was associated with decreased unsterile syringe use.

Given the dearth of evidence on the effects of spatial pharmacy access, the influence of this construct on pharmacy syringe purchases and injection risk behavior is unclear. As above, the inconsistency of results regarding injection risk behavior may be attributable to the use of different outcome measures. However, additional research is needed to better understand how spatial pharmacy access shapes behavior among PWID.

Additional Studies

Additional studies have begun to examine other aspects of the neighborhood context as potential determinants of injection drug use behavior. Although current evidence is insufficient to evaluate their influence on PWID, this evidence is described below.

Spatial access to other health services and health service utilization

Closely akin to analyses examining the influence of proximity on the use of SEPs and pharmacies, two studies examined whether spatial access to other health services was associated with their use.[112,113] Among a sample of 219 Mexican American heroin injectors in Houston, Texas, Kao and colleagues investigated whether the proximity and density of substance abuse treatment facilities was associated with seeking or receiving substance abuse treatment.[112] These associations were null, even after substance abuse treatment facilities were restricted to those offering services in Spanish. In a similar study, Hadland and colleagues investigated the relation between spatial access to a supervised injection facility (SIF) and recent facility use. Among a sample of 414 adolescent and young adult PWID in Vancouver, Canada, they found that participants who lived or spent time in the neighborhood surrounding the SIF were more likely to report having used the facility.

Neighborhood context as an effect modifier

Finally, one study examined neighborhood-level characteristics as potential effect modifiers of an association observed at the individual level.[114] Among a sample of 144 PWID in Baltimore, Maryland, Fuller and colleagues conducted an analysis to determine whether census tract-level socioeconomic and demographic characteristics modified the relation between race and age at initiation of injection drug use.[114] Analyses revealed that the relation was not modified by the proportion of census tract residents living in poverty or the proportion of employed men ≥16 years of age. However, a significant three-way interaction was detected between race, the proportion of residents with at least a high school education, and the proportion of minority residents. African American PWID who lived in neighborhoods with high percentages of minority residents and fewer high school graduates were more likely to report initiation of drug injection before age 22 in comparison to white PWID living in neighborhoods with low minority percentages and more high school graduates.

DISCUSSION

Our systematic review summarizes the extant literature about the influence of neighborhood context on injection drug use behavior. This is an emerging area of research, and as a result, we found that few published analyses exist on this topic. Although our ability to make definitive conclusions with regard to specific temporal and causal relationships was limited, existing research suggests that certain aspects of the neighborhood environment may shape behavior among PWID. Early evidence suggests that neighborhood socioeconomic disadvantage may be related to increased injection drug use, although further studies of this association are needed in different geographic contexts. The relation between neighborhood socioeconomic disadvantage and injection risk behavior is less clear, given the inconsistency of extant results. However, reasonably consistent support links spatial SEP access to increased SEP utilization and decreased injection risk behavior. The existence of a relation between spatial pharmacy access and injection drug use behavior remains unclear.

Limitations of the extant literature

The literature on neighborhood and injection drug use behavior is limited not only by a dearth of studies, but also by a number of methodological and conceptual challenges. We discuss these limitations below and offer recommendations for future research.

Few longitudinal studies

Our current understanding of links between neighborhood context and injection drug use behavior is limited by the small number of longitudinal studies that have been conducted on this topic. Cross-sectional studies are often more practical to conduct, given the financial and temporal burdens associated with the collection of longitudinal data, and as a result, the majority of studies included in this review were cross-sectional in nature. However, longitudinal studies are necessary to establish temporality and to appropriately measure neighborhood effects. Associations detected between neighborhood characteristics and injection drug use behavior among PWID in cross-sectional studies may be the

spurious byproduct of selection into neighborhoods on the basis of individuals' injection drug use. For example, individuals who initiate drug injection may experience a decline in their individual socioeconomic status, leading them to relocate to poorer neighborhoods with greater social disorder. A cross-sectional study of the relation between neighborhood social disorder and injection drug use might then detect an association between these constructs, although a causal relation may not exist. Longitudinal studies that relate neighborhood characteristics to changes in injection drug use behavior over time are necessary to avoid this threat to causal inference. Future research should also track the mobility of PWID over time to study the cumulative effect of neighborhood exposures on outcomes associated with injection drug use.

Inconsistent measurement of neighborhood characteristics

The literature reviewed above is also limited by the lack of consistency with which neighborhoods were defined and measured. Although census tracts were often used as proxies for neighborhood, larger geographic units, including neighborhood statistical areas and health districts, were also used to measure area-level effects. The lack of agreement regarding the spatial scale on which neighborhoods should be defined makes it difficult to compare results across studies, and subsequently, to draw conclusions with respect to the influence of neighborhood on injection drug use behavior. Additional studies are needed to explore the measurement of area-level characteristics in the context of outcomes associated with injection drug use. However, it is important to note that the method through which neighborhoods are defined and measured will likely vary with the constructs under study. For example, when examining the influence of a social construct, like collective efficacy, it may be appropriate to rely on participants' perceptions of their neighborhoods, whereas structural constructs, like SEP availability, may be better studied using geographically-defined areas. Although administratively-defined units are often used to approximate neighborhoods, as was the case for several analyses in this review, these units may not necessarily reflect the geographic space to which individuals are exposed. Therefore, future studies should use ego-centered areas (e.g. buffers centered on participants' residences) or GPS activity spaces to approximate neighborhoods of interest whenever possible.[115] The radii of ego-centered areas could also be manipulated in sensitivity analyses to investigate how differences in spatial scale influence study findings.

Studies conducted in few research settings

Another limitation of the extant literature on neighborhood context and injection drug use behavior is the limited generalizability of the settings in which the studies were conducted. As described above, all of the studies identified for inclusion in this review utilized data from the United States, Canada, or Scotland. These are all developed country contexts, in which the relation between neighborhood and injection drug use behavior may not reflect that in parts of the world where resources are more scarce and the stigma associated with injection drug use may vary. Data have shown that developing regions, such as Eastern Europe and South America, have some of the highest prevalences of injection drug use and BBVs among PWID.[11,116] Additional research on how neighborhood and other elements of the risk environment influence injection drug use behavior in these regions is urgently needed to curb epidemics of injection drug use and BBVs worldwide.

A related issue is the fact that nearly all of the reviewed studies examined data from urban environments. Although the density of the drug injecting population may be higher in cities than in suburban or rural areas, injection drug use behaviors occurring outside of urban contexts should not be ignored. This point is particularly salient considering the impact that prescription opioid abuse has had on the geographic distribution of heroin use in the United States. Prescription opioid abuse has become especially prevalent in suburban contexts, where residents are more likely to have health insurance, and therefore, access to prescription drugs. As prescription opioids have become more expensive and less readily available for non-medical use, some opioid abusers have shifted to heroin, progressing in some cases to heroin injection.[117-128] As a result, although heroin use has traditionally been concentrated in inner-city, minority neighborhoods, recent research has shown that new heroin users are more likely to reside outside of large urban areas in neighborhoods with predominantly white populations.[129] Critically, both healthcare and harm reduction resources targeted to PWID may be less available in these settings, making injectors in these areas especially vulnerable to the harms associated with injection drug use. Under these conditions, BBVs may be more easily transmitted and go undetected for longer periods, fostering the development of BBV epidemics. Future studies are needed to examine how neighborhood-level factors shape injection drug use behavior in non-urban areas.

Furthermore, nearly all of the literature about neighborhood context and injection drug use behavior is focused on the influence of the residential neighborhood. While the residential context is likely an influential element of the risk environment, other spatial locations may be of importance as well. Two contexts that warrant further study are the areas surrounding the drug-buy and injection locations. For many PWID, the residential, drug-buy, and injection locations may be in such close geographic proximity that it is not possible to disentangle the independent influence of each on injection drug use behavior. However, current evidence indicates that at least some PWID commute among these locations, creating the opportunity to examine the potential influence of each local-area context separately.[109,110] When designing harm reduction interventions geared toward PWID, it may ultimately prove more effective to target areas in which drugs are purchased and used as opposed to neighborhoods in which PWID live.

Few neighborhood characteristics have been investigated

Our ability to draw conclusions regarding the influence of neighborhood context on injection drug use behavior was also curtailed by the fact that few neighborhood-level characteristics have been examined as potential determinants of behavior among PWID. As described above, the only features of the local environment that have been studied in any depth are neighborhood socioeconomic context, SEP proximity, and pharmacy proximity. Beyond deepening our knowledge of neighborhood characteristics that have already been investigated, future research should also incorporate elements of the neighborhood context that have yet to be studied.

Many aspects of the social environment, in particular, deserve further inquiry. Examples include collective efficacy, social capital, and the stigma associated with injection drug use. Collective efficacy, defined as a combination of social cohesion and the willingness to take civic action,[130] has been shown to impact violence,[131] asthma,[132] birth weight,[133] and age at first sexual intercourse.[134] Given the diversity of outcomes to which this construct has already been linked, collective efficacy may influence injection drug use behavior as well. Similarly, social capital has been described as an indicator of access to resources and can be measured at both the individual and neighborhood levels.[135] Studies have shown that social capital is linked to substance use and potentially HIV status,[136-142] suggesting that it may shape behaviors

surrounding drug injection as well. Less work has been conducted on the influence of injection drug use stigma, but this is another potentially fruitful area of inquiry. Existing evidence suggests that health-related stigma may pose a barrier to accessing health and social services.[91,143-145] PWID who reside in communities with the highest levels of injection drug use stigma may experience increased psychological distress and be less likely to access syringes from safe sources. As a result, these PWID may be more likely to engage in high-risk injection behaviors.

Inadequate examination of mediators and modifiers

Developing our understanding of the influence of neighborhood on injection drug use behavior will also require the identification of factors that mediate and modify these relationships. However, few of these third variables have been investigated. Of the 22 studies reviewed above, only one included a potential mediator,[41] while few others examined effect modification. The identification of both mediators and modifiers will be necessary to intervene effectively on elements of the neighborhood context that shape injection drug use behavior. Mediators may represent additional targets for intervention, while modifiers may identify populations in which these interventions will have the greatest effect. For example, neighborhood-behavior relations may be modified by individual-level sociodemographic characteristics (e.g. gender, age, race). Targeting interventions to groups that are most affected by characteristics of the neighborhood environment may increase their public health impact.

Finally, investigating the interplay of neighborhood-level factors in shaping injection drug use behavior should not be under-emphasized. The studies included in this review identified multiple elements of the neighborhood context that may influence outcomes among PWID; however, only two analyses sought to understand how the effect of one area-level characteristic was modified by the presence of another.[48,49] These are the analyses by Cooper and colleagues in which drug-related police activity was investigated as a potential modifier of associations between spatial SEP access and unsterile syringe use. A complete understanding of how local environments shape injection drug use behavior will require further examination of both mediating and modifying pathways.

Strengths and limitations of the review

The findings in this review should be considered in light of specific strengths and limitations. With regard to strengths, this is the first systematic review, of which we are aware, to summarize and synthesize the literature about the relation between neighborhood context and injection drug use behavior. Describing the work that has been done in this field may motivate future research on the influence of neighborhood-level factors on PWID. Second, a very large number of abstracts was screened (n = 4,578) to ensure that all extant studies pertaining to our topic were identified. The fact that no additional studies were identified by a hand search of selected articles' citations supports the notion that our original search strategy was comprehensive.

With regard to limitations, our search was restricted to articles published in the peer-reviewed literature. Therefore, articles from the grey literature were not included, and it is possible that our findings were influenced by publication biases toward positive results. Second, the relatively small number of studies included in the review prevented us from using meta-analyses to investigate relations between elements of the neighborhood context and injection drug use behavior.

Conclusion

Quantitative analyses regarding the influence of neighborhood-level characteristics on PWID are only beginning to emerge. Our systematic review of this literature has identified both methodological challenges and gaps in current knowledge that highlight the need for additional research on this topic. As studies on injection drug use behavior move beyond the identification of individual-level determinants, enhancing our understanding of pathways linking neighborhood-level factors to individual behavior among PWID will be of paramount importance to curbing BBV transmission in this population.

CHAPTER 2 TABLES AND FIGURES

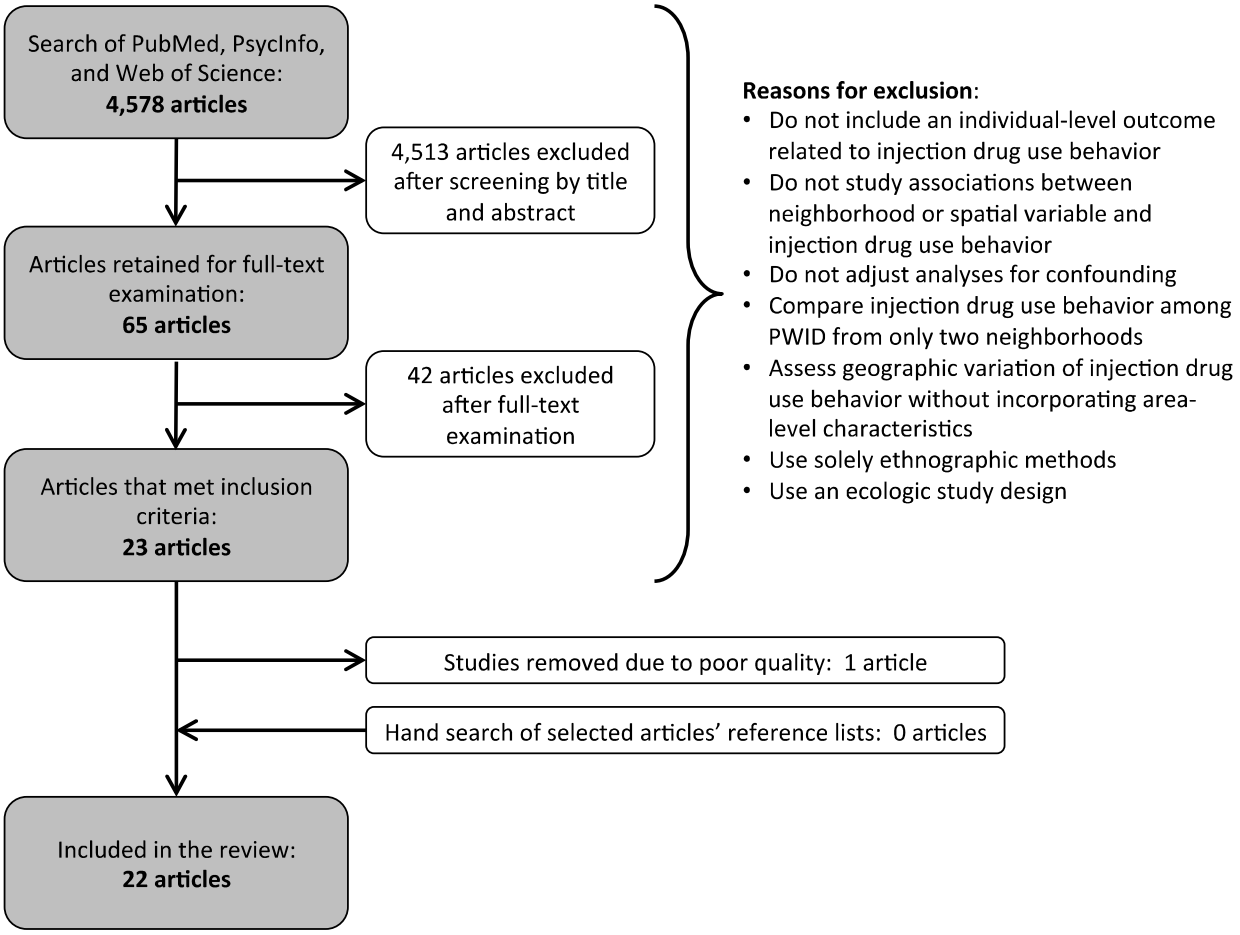


Figure 2.1. Process through which articles were identified for inclusion in the review (See Appendix B for a detailed explanation of the search strategies used in PubMed, PsycInfo, and Web of Science)

Table 2.1. Studies regarding the influence of neighborhood context on injection drug use behavior

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Bluthenthal et al. 2007 [42]	Cross-sectional analysis of the relation between neighborhood socioeconomic characteristics and syringe sharing	San Francisco Bay area, California	4,589 PWID enrolled in the Urban Health Study	Socioeconomic and demographic characteristics of the census tract of residence: • Percent of households on public assistance • Percent male unemployment • Median household income • Percent African American • Global measure of neighborhood deprivation	• Receptive syringe sharing in the past 6 months • Distributive syringe sharing in the past 6 months	A 10% increase in the percent of residents in the census tract who identified as African American was associated with modest decreases in the likelihood of both receptive syringe sharing (AOR=0.93, 0.89-0.99) and distributive syringe sharing (AOR=0.94, 0.89-0.99). None of the other neighborhood-level characteristics examined were significantly associated with syringe sharing in adjusted models.
Bruneau et al. 2008 [60]	Cross-sectional analysis of the influence of SEP and pharmacy proximity on high-risk injection behavior	Montreal, Canada	456 PWID who obtained at least some of their syringes from sources other than health clinics	Euclidean distance in meters from each participant's postal code of residence to: • The nearest SEP site • The nearest pharmacy	• High-risk injection behavior, defined as agreement with any of the following in the past 6 months: 1) Having shared injection material at least 5 times 2) Having injected with strangers at least 5 times 3) Having shared injection material with a known HIV-positive person	Neither proximity to SEP sites nor proximity to pharmacies selling syringes over-the-counter were associated with high-risk injection behavior in adjusted analyses.

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Cooper et al. 2011 [47]	Serial cross-sectional analysis of the influence of spatial access to SEPs and pharmacies on sterile syringe use	New York, New York	4,003 PWID entering the Beth Israel Hospital detoxification program from 1995-2006 who enrolled in the Risk Factors for AIDS among Intravenous Drug Users Study	• Spatial access to SEP sites, defined as the percent of the health district of residence within 0.25 miles, 0.5 miles, and 1 mile of an SEP site • Spatial access to pharmacies, defined as the percent of the health district of residence within 0.25 miles, 0.5 miles, and 1 mile of a pharmacy selling syringes over-the-counter	• Use of a sterile syringe in ≥75% of injection events in the past 6 months	When 1 mile-radii were used to measure SEP access, higher SEP access was associated with increased sterile syringe use. Effect estimates generated by the use of 0.25 mile and 0.5 mile radii were similar in magnitude and direction. When spatial access to pharmacies selling syringes over-the-counter was added to these models, higher pharmacy access was also associated with increased sterile syringe use. SEP access coefficients were unaffected by the addition of a pharmacy access variable to the model.
Cooper et al. 2012a [48]	Serial cross-sectional analysis of the influence of spatial access to SEP sites, drug-related arrest rates, and spatial access to pharmacies on injection risk behavior	New York, New York	4,067 PWID entering the Beth Israel Hospital detoxification program from 1995-2006 who enrolled in the Risk Factors for AIDS among Intravenous Drug Users Study	• Spatial access to SEP sites, defined as the percent of the health district of residence within 1 mile of an SEP site • Drug-related arrest rate/1000 adults in the health district of residence • Spatial access to pharmacies, defined as the percent of the health district of residence within 1 mile of a pharmacy selling syringes over-the-counter	• Use of an unsterile syringe in ≥75% of injection events in the past 6 months • Distributive syringe sharing in the past 6 months	In health districts with low drug-related arrest rates, higher SEP access in 1995 was associated with decreased unsterile syringe use. Higher drug-related arrest rates appeared to erode this protective effect; however, changes in SEP access and drug-related arrest rates after 1995 were not associated with unsterile syringe use. Increased pharmacy access was linked to decreased unsterile syringe use. A marginal inverse association was observed between SEP access and distributive syringe sharing, while drug-related arrest rates and pharmacy access were not associated with this outcome.

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Cooper et al. 2012b [49]	Serial cross-sectional analysis of the influence of spatial access to SEP syringes, drug-related arrest rates, and spatial access to pharmacies selling syringes on unsterile syringe use	New York, New York	4,067 PWID entering the Beth Israel Hospital detoxification program from 1995-2006 who enrolled in the Risk Factors for AIDS among Intravenous Drug Users Study	• Spatial access to sterile syringes from SEP sites, defined as the average number of syringes distributed by SEPs across the health district of residence • Drug-related arrest rate/1000 adults in the health district of residence • Spatial access to pharmacies, defined as the percent of the health district of residence within 1 mile of a pharmacy selling syringes over-the-counter	• Use of an unsterile syringe in ≥75% of injection events in the past 6 months	In health districts with low drug-related arrest rates, higher access to SEP syringes in 1995 was associated with decreased unsterile syringe use. Higher drug-related arrest rates appeared to erode this protective effect. Although no association was observed between changes in drug-related arrest rates after 1995 and unsterile syringe use, a marginal inverse association was detected between changes in SEP syringe access after 1995 and this outcome. Increased pharmacy access was also linked to decreased unsterile syringe use.
Fuller et al. 2005 [114]	Cross-sectional analysis of whether the relation between race and age at initiation of injection is modified by neighborhood socioeconomic characteristics	Baltimore, Maryland	144 PWID aged 15-30 years who had been injecting for 2-5 years and were enrolled in the Risk Evaluation and Assessment of Community Health (REACH II) Study	Socioeconomic and demographic characteristics of the census tract in which participants were recruited: • Percent of residents living in poverty • Percent employed among adults ≥16 years of age • Percent of residents with a high school diploma or equivalent • Percent minority residents	• Age at initiation of injection drug use	The association between race and age at initiation of injection drug use was modified by neighborhood minority composition and educational attainment in a three-way interaction. African Americans who lived in neighborhoods with high percentages of minority residents and low levels of educational attainment were nearly 4 times as likely to initiate injection drug use during adolescence as their white counterparts living in neighborhoods with low minority percentages and higher educational attainment (AOR=3.66, 2.11-6.34).

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Genberg et al. 2011 [104]	Longitudinal analysis of the influence of neighborhood deprivation and residential relocation on long-term injection cessation	Baltimore, Maryland	1697 PWID enrolled in the AIDS Linked to the Intravenous Experience (ALIVE) cohort	• Neighborhood deprivation, defined as the score on an index created from 8 census tract-level characteristics of the census tract of residence	• Long-term injection cessation, defined as abstinence from injection drug use for 6 consecutive study visits (3 years)	Increased neighborhood deprivation was associated with decreased long-term injection cessation. Similarly, compared with continuously living in less deprived neighborhoods, staying in the most deprived neighborhoods was associated with decreased long-term injection cessation. Relocating from the most deprived to less deprived neighborhoods was associated with increased long-term injection cessation, as was relocating within less deprived neighborhoods. There was no association between long-term injection cessation and moving within the most deprived neighborhoods or moving from a less deprived neighborhood into the most deprived neighborhoods.
Genereux et al. 2010 [43]	Cross-sectional analysis of the relation between neighborhood socioeconomic characteristics and high-risk injection behavior	Montreal, Canada	468 PWID enrolled in the St. Luc Cohort	• Neighborhood socioeconomic disadvantage, defined as the percent of households below the low-income cutoff (LICO) within a circular 500m-radius buffer centered on participants' residential postal code • Neighborhood educational attainment, defined as the percent of adults with a university degree in the same 500m-radius buffer	• High-risk injection behavior, defined as agreement with any of the following in the past 6 months: 1) Having shared injection material at least 5 times 2) Having injected with strangers at least 5 times 3) Having shared injection material with a known HIV-positive person	Among PWID in the inner city, neighborhood socioeconomic disadvantage was associated with increased high-risk injection behavior, while low neighborhood educational attainment was associated with decreased high-risk injection behavior. Neighborhood socioeconomic characteristics were not associated with high-risk injection behavior among PWID in boroughs outside the inner city area.

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Gindi et al. 2009 [108]	Longitudinal analysis of the relation between SEP proximity and SEP retention	Baltimore, Maryland	12,388 PWID enrolled in the Baltimore Needle Exchange Program (BNEP) from 1994-2005	• Proximity to the BNEP site at which participants enrolled in the program, defined as whether the client's zip code at enrollment matched the zip code of the BNEP site where the client enrolled	• Multi-visit usage of the BNEP, defined as visiting a BNEP site at least once in the 12 months following the enrollment visit • Number of return visits to BNEP sites during the first 12 months of enrollment	PWID whose zip code matched that of the BNEP site at which they enrolled were 49% more likely to visit a BNEP site at least once within the next 12 months in comparison to PWID who reported a different zip code (AOR=1.49, 1.38-1.62). In addition, PWID whose zip code matched that of the enrollment site visited BNEP locations at more than 4 times the rate of their counterparts who reported different zip codes (Adjusted IRR=4.16, 2.64-6.56).
Hadland et al. 2014 [113]	Cross-sectional analysis of the relation between supervised injection facility (SIF) proximity and SIF use	Vancouver, Canada	414 adolescent and young adult PWID enrolled in the At-Risk Youth Study cohort	• Having lived or spent time in Downtown Eastside (the neighborhood surrounding Vancouver's SIF) in the past 6 months	• Use of Vancouver's SIF in the past 6 months	Adolescent and young adult PWID who lived or spent time in the neighborhood surrounding Vancouver's SIF (Downtown Eastside) were more than three times as likely to report SIF use as those who did not (AOR=3.29, 2.38-4.54).
Hutchinson et al. 2000 [45]	Cross-sectional analysis of the influence of SEP proximity on receptive syringe sharing	Glasgow, Scotland	2,567 PWID	• Proximity to an SEP site, defined as the direct distance in miles from the center of each participant's postcode district of residence to the nearest SEP site	• Injection with a used needle or syringe in the past 6 months	PWID who resided >1 mile from an SEP site were marginally more likely to have injected with a used needle or syringe in the past 6 months in comparison to their counterparts who lived ≤1 mile from an SEP site (AOR=1.25, 1.00-1.57).

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Kao et al. 2014 [112]	Cross-sectional analysis of the influence of spatial accessibility of substance abuse treatment facilities on treatment use and drug purchasing behavior	Houston, Texas	219 current and former Mexican American heroin injectors aged 45 years and older enrolled in Project CHIVA	Minutes of driving time from a participant's residence to: • The closest substance abuse treatment facility • The closest substance abuse treatment facility providing services in Spanish Number of substance abuse facilities within a 10-minute driving distance of a participant's residence, including: • All facilities • Facilities providing services in Spanish	• Ever sought substance abuse treatment • Ever received substance abuse treatment • Location of last heroin purchase, defined as either inside or outside the participant's neighborhood of residence	No associations were found between any of the variables measuring spatial accessibility of substance abuse treatment facilities and having sought or received treatment. However, current heroin users who lived near a greater number of Spanish-serving treatment facilities were more likely than former heroin users who lived near fewer Spanish-serving facilities to purchase their last heroin inside their neighborhood of residence. Similarly, current heroin users who resided farther from a Spanish-serving facility were less likely than former heroin users who resided closer to a Spanish-serving facility to purchase their last heroin inside their neighborhood of residence.
Latkin et al. 1998 [146]	Cross-sectional analysis of the relation between the proximity of high drug use areas on the type and frequency of drug injection	Baltimore, Maryland	597 PWID enrolled in the Stop AIDS for Everyone (SAFE) study, some of whom were recruited from the ALIVE study	Distance in meters from the participant's residence to: • The SAFE study clinic • The Baltimore City Health Department's Western District STD Clinic NOTE: The SAFE study clinic and the Western District STD clinic were chosen to represent areas of Baltimore with a high prevalence of drug users.	• Daily heroin injection in the past 6 months • Daily cocaine injection in the past 6 months	After controlling for a variety of neighborhood socioeconomic and demographic characteristics, distance from the participant's residence to the Western District STD clinic was inversely associated with daily cocaine injection, and not associated with daily heroin injection. Distance to the SAFE study clinic was not associated with either outcome.

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Latkin et al. 2005 [41]	Cross-sectional analysis of the influence of neighborhood social disorder on injection frequency and equipment sharing	Baltimore, Maryland	701 PWID enrolled in the Self-Help in Eliminating Lethal Diseases (SHIELD) study	• Neighborhood social disorder, measured by 7 items asking participants how big of a problem each of the following was in their neighborhoods: vandalism, vacant housing, litter or trash on the street, loitering teens, burglary, drug selling, and robbery or assault	• Injection frequency in the past 6 months • Injection equipment sharing in the past 6 months	Structural equation models were used to measure the influence of neighborhood social disorder on injection frequency and equipment sharing, including psychological distress as a potential mediator of the relations. Analyses indicated that distress is higher in more socially disordered neighborhoods, that distress leads to greater injection frequency and equipment sharing, and that injection frequency predicts equipment sharing.
Linton et al. 2014 [105]	Longitudinal analysis of the influence of neighborhood residential rehabilitation and residential relocation on injection drug use	Baltimore, Maryland	1818 current and former PWID enrolled in the ALIVE cohort	• Neighborhood residential rehabilitation, defined as the percentage of residential properties in the participant's neighborhood statistical area of residence where investment in interior or exterior maintenance exceeded $5000 USD for a given year	• Injection drug use in the past 6 months	Increased residential rehabilitation was associated with decreased injection drug use. When compared to continuous residence in neighborhoods with low residential rehabilitation, the following relocation patterns were associated with decreased injection drug use: continuous residence in neighborhoods with higher residential rehabilitation, relocation between neighborhoods with higher residential rehabilitation, and relocation from neighborhoods with low residential rehabilitation to higher residential rehabilitation.

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Martinez et al. 2014 [110]	Cross-sectional analysis of the influence of activity space distance and SEP accessibility on syringe sharing	San Francisco, California	989 street-recruited PWID enrolled in the Urban Health Study	• Activity space distance, defined as the distance in miles along the street network from where a participant usually slept, to where he hung out during the day, to where he used drugs in the past 6 months • SEP accessibility, defined as whether an SEP was located within 50 meters of the activity space path	• Receptive or distributive syringe sharing in the past 6 months	Neither activity space distance nor SEP accessibility were associated with syringe sharing in the past 6 months.
Nandi et al. 2010 [103]	Longitudinal analysis of the relation between neighborhood poverty and injection cessation	Baltimore, Maryland	1875 PWID enrolled in the ALIVE cohort	• Neighborhood poverty, defined as the percent of residents living in poverty in the participant's census tract of residence	• Injection cessation, defined as abstinence from injection drug use in the past 6 months	Analyses conducted using traditional regression techniques found no significant association between neighborhood poverty and injection cessation in fully adjusted models. However, in analyses that were adjusted for confounding using inverse probability weights, neighborhood poverty was associated with injection cessation. Compared with living in a neighborhood in the highest category of poverty (>30% of residents in poverty), living in a neighborhood in the second (>20% but ≤30%), third (>10% but ≤20%), and fourth (≤10%) categories of poverty was associated with 20% (AOR=1.20, 1.03-1.41), 35% (AOR=1.35, 1.12-1.63), and 44% (AOR=1.44, 1.14-1.82) increased odds of injection cessation, respectively.

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Rockwell et al. 1999 [44]	Cross-sectional analysis of the influence of SEP proximity on SEP use and receptive syringe sharing	New York, New York	776 PWID	• Proximity to an SEP site, defined as participants' self-report of the time it would take to get to an SEP site from "where they usually stayed"	• "Typically" obtained needles from SEPs in the past 6 months • Receptive sharing at the last injection	PWID who reported living within a 10-minute walk of an SEP site were more than 2 times as likely to "typically" obtain needles from SEPs in comparison to those who lived farther away (AOR=2.89, 2.06-4.06). PWID who lived within a 10-minute walk of an SEP site were also less likely to report receptive syringe sharing at the last injection (AOR=0.45, 0.24-0.86).
Schilling et al. 2004 [46]	Cross-sectional analysis of the influence of SEP proximity on injection risk behavior and drug treatment participation	New York, New York	587 PWID enrolled in the Collaborative Intravenous Drug Users Studies	• Proximity to an SEP site, defined as recruitment into the study from the East Harlem SEP site, within 10 blocks of the SEP site, or greater than 10 blocks from the SEP site	Injection risk behavior in the past 6 months: • Used needle after others squirted drugs into it • Shared needles with other injectors • Used dirty needles by yourself • Never used new needle • Shared same cooker with another injector Drug treatment participation: • Attended a drug treatment program in the past 6 months • Currently enrolled in a drug treatment program	PWID recruited to the study at the East Harlem SEP site were less likely to use a needle after others squirted drugs into it and to use dirty needles by themselves than participants who were recruited from the surrounding area. SEP proximity was not associated with the likelihood of sharing needles with others, never using a new needle, or sharing the same cooker. PWID recruited to the study from within 10 blocks of the SEP site were more likely to report drug treatment in the past 6 months and current drug treatment than those recruited at the SEP site and greater than 10 blocks from the SEP.

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Sherman et al. 2004 [106]	Longitudinal analysis of the influence of perceived severity of drug selling in the neighborhood and having traveled within the same area of town to buy drugs on drug use cessation	Baltimore, Maryland	200 heroin injectors enrolled in the SHIELD study	• Perceived severity of drug selling in the neighborhood, defined as whether participants reported that drug selling in their neighborhoods was either "a problem" or "not a problem" • Having traveled within the same area of town in which one lives to buy drugs	• Injection drug use in the past 6 months	When perceived severity of drug selling in the neighborhood and having traveled within the same area of town to buy drugs were included in the same multivariable model, perceived severity of drug selling was not associated with injection drug use. However, participants who reported traveling within the same area of town to buy drugs at baseline were more than 4 times as likely to report injection drug use at 6-month follow-up in comparison to their counterparts who did not travel within the same area of town to buy drugs (AOR=4.77, 1.62-13.99).
Stopka et al. 2012 [111]	Cross-sectional analysis of the relation between spatial accessibility of pharmacies selling syringes over-the-counter and pharmacy syringe purchase	San Francisco, California	563 PWID	• Number of pharmacies within a 0.25-mile radius of the intersection closest to a participant's usual residence Distance from a participant's intersection to the nearest pharmacy selling syringes over-the-counter, measured as: • Euclidean distance in miles • Walking distance in miles along the street network • Walking time in minutes	• Pharmacy syringe purchase in the past 6 months	Euclidean distance, walking distance, and walking time to the nearest pharmacy selling over-the-counter syringes were not associated with pharmacy syringe purchase in crude models. As a result, these variables were not included in adjusted analyses. Number of pharmacies within a 0.25-mile radius of the residence was associated with pharmacy syringe purchase in a crude model, but not in adjusted analyses.

Reference	Study Description	Location	Sample	Contextual variables	Injection drug use behavior outcome	Results
Williams and Metzger 2010 [109]	Cross-sectional analysis of the influence of spatial accessibility of SEPs, drug buy, and drug use locations on injection risk behavior	Philadelphia, Pennsylvania	1,443-1,776 PWID included in the prescreening database of the HIV Prevention Trials Network 037 study NOTE: Sample sizes for final analyses varied according to the completeness of the data.	Distance in miles along the street network from the nearest SEP site to: • The participant's residence • The drug buy location • The injection location Path distance in miles from: • The residence to the drug buy to the injection location • The nearest SEP site to the residence to the drug buy to the injection location Average distance among: • The residence, drug buy, and injection locations • The nearest SEP, the residence, the drug buy, and the injection locations	• Place of most recent injection, defined as either a public place, a shooting gallery, or own/family's/friend's residence • Usual source of syringes, defined as either an SEP or a non-SEP • Receptive sharing of syringes in the past 3 months • Receptive sharing of water, cookers, or cotton in the past 3 months	For each 1-mile increase in the distance between participants' residences and the nearest SEP site, there was a 6% increase in the likelihood of using non-SEP sources for syringe access (AOR=1.06, 1.02-1.10). Blacks were significantly less likely than whites to inject in public places as the path distance from the residence to drug buy location to injection location increased (AOR=0.94, 0.90-0.98). Latinos were much more likely than whites to access syringes from non-SEP sources as the distance from the nearest SEP to drug buy (AOR=6.70, 2.32-19.4) and injection locations (AOR=5.35, 2.53-11.3) increased. Latinos were also more likely than whites to engage in receptive sharing of syringes (AOR=1.21, 1.04-1.40) and other injection equipment (AOR=1.24, 1.03-1.47) as the average distance among SEP, residence, drug buy, and injection locations increased.

Table 2.2. Pattern of findings for relations between aspects of the neighborhood context and injection drug use behavior [a,b]

Neighborhood characteristic	Association with injection drug use behavior		
	Injection drug use/Injection frequency	Injection risk behavior [c]	Acquisition of syringes from SEPs or pharmacies
Neighborhood socioeconomic characteristics			
Neighborhood socioeconomic disadvantage	+[103] +[104] +[105]	**M**[43] **0**[42]	
Neighborhood social disorder	+[41] **M**[106]	+[41]	
Percent African American		-[42]	
Sterile syringe access			
Spatial access to SEP sites		-[44] -[45] **M**[47] **0**[60] **0**[46] **0**[110]	+[44] +[108] +[109]
Spatial access to pharmacies selling syringes over-the-counter		**M**[47-49] **0**[60]	**0**[111]

[a] Direction of associations identified: + = significant positive association; - = significant negative association; 0 = no association; M = mixed results

[b] If an association was reported in multiple papers whose analyses utilized the same measures and data, their findings are reported once with multiple references.

[c] In this table, "injection risk behavior" refers to injection behaviors that increase the risk of BBV transmission, e.g. receptive syringe sharing, distributive syringe sharing, unsterile syringe use, and sharing of other injection equipment (cookers, water, etc.).

CHAPTER 3: The influence of neighborhood socioeconomic disadvantage on high-risk injection behavior among people who inject drugs

INTRODUCTION

High-risk injection behaviors, such as syringe sharing and syringe reuse, facilitate the spread of HIV, HCV, and other infections among people who inject drugs (PWID).[2,3] Research on the determinants of high-risk injection behavior has traditionally concentrated on factors operating at the individual level. However, evidence gathered over the past twenty years suggests that interventions focused solely on individual behavior change will be insufficient to eliminate risky injection practices among PWID.[98,99] More recent work suggests that high-risk injection behavior is shaped not only by individual-level factors, but also by the environment in which these behaviors occur.[41-47] Several authors have written conceptual papers describing how HIV risk is influenced by contextual factors, but the paradigm most often cited is that proposed by Rhodes and colleagues in their writings on the risk environment.[50,51,53] According to this paradigm, the risk environment is the space in which physical, social, political, and economic factors exogenous to the individual interact to shape the transmission of blood borne viruses (BBVs) among PWID.

One element of the risk environment that remains understudied in the context of high-risk injection behavior is neighborhood socioeconomic disadvantage. Neighborhood disadvantage has been linked to numerous health conditions and behaviors, ranging from all-cause mortality to smoking;[55] however, the relation between this construct and high-risk injection behavior remains unclear. To date, at least two studies have investigated this association, each yielding different results. The first, conducted among PWID in the San Francisco Bay area, found that census tract-level measures of socioeconomic disadvantage were not associated with receptive syringe sharing.[42] Conversely, the second found that neighborhood-level measures of poverty and educational attainment were associated with high-risk injection behavior among inner-city PWID in Montreal, Canada.[43] Interestingly, the associations detected in the Montreal-based study were in opposite directions. Poverty was linked to increased high-risk injection behavior, while low educational attainment was linked to decreased high-risk injection behavior. Together, these results offer conflicting perspectives as to whether neighborhood disadvantage influences injection practices, and if so, how. Equivocal results may be explained, in part, by the fact that neighborhood disadvantage may shape high-risk injection behavior through several pathways. For example, poor neighborhoods may have more open drug markets and larger networks of injectors with

whom to share syringes, both of which may increase risky injection practices. However, the same areas may also have a higher availability of health and social services geared toward PWID, which may decrease high-risk injection behavior.

In addition to emphasizing the influence of contextual factors on individual-level behavior among PWID, the risk environment paradigm also emphasizes the interplay of these factors in shaping outcomes.[53] With this in mind, it may be meaningful to examine how neighborhood socioeconomic disadvantage operates in the context of other area-level influences on high-risk injection behavior. Previous research has identified two area-level characteristics that warrant consideration: syringe exchange program (SEP) accessibility and drug-related police activity. SEPs decrease high-risk injection behavior by increasing sterile syringe access and educating PWID on the dangers associated with injection equipment sharing. Studies have shown that the proximity of injectors' residences to SEP sites is associated with increased SEP participation and decreased syringe sharing.[44,45,47,108,109] Conversely, drug-related police activity has been linked to increased high-risk injection behavior.[74,75] This is supported by qualitative evidence showing that PWID are afraid of being stopped by police for fear of violence and arrest.[61-66] Negative encounters with law enforcement may discourage PWID from carrying sterile injection equipment and from visiting SEPs and pharmacies to acquire new syringes.[66-69] As a result, PWID in neighborhoods with high drug-related police activity may be less likely to access sterile syringes and practice riskier injection behaviors. Consistent with this hypothesis, studies conducted in Oakland, California; Philadelphia, Pennsylvania; and Vancouver, Canada have all linked police crackdowns in high drug use neighborhoods to unsafe injection behaviors and decreased SEP attendance.[69,71,73]

To contribute to and clarify the literature about the role of neighborhood environment in the etiology of high-risk injection behavior in PWID, we examined relations between common measures of neighborhood socioeconomic disadvantage and high-risk injection behavior among a sample of PWID in New York City. In addition, we examined whether associations between neighborhood socioeconomic disadvantage and high-risk injection behavior were modified by SEP accessibility and drug-related police activity.

METHODS

Subjects and setting

The current analyses use data from the Pharmacists as Resources Making Links to Community Services (PHARM-Link) study, which has been described elsewhere.[147] Briefly, the PHARM-Link study is a pharmacy-randomized intervention trial designed to evaluate the impact of pharmacy-delivered health and social service referrals on a variety of outcomes among pharmacy staff and PWID. Previous studies have shown that, in addition to distributing sterile syringes, SEPs are instrumental in linking PWID to health and social services, such as HIV testing and drug treatment. The purpose of PHARM-Link was to evaluate the extension of this public health role to pharmacies.

ESAP-registered pharmacies in high drug activity neighborhoods in New York City were invited to participate in the study. A total of 71 pharmacies were randomized to intervention and primary control arms in roughly equal numbers. Intervention pharmacies offered PWID referrals to health and social services via print materials and a drug user-specific web resource guide, while primary control pharmacies offered only standard syringe sales services. PWID were recruited into PHARM-Link when visiting study pharmacies to purchase nonprescription syringes. During syringe transactions with PWID, pharmacy staff were trained to discreetly describe the PHARM-Link study and to offer a study appointment with research staff within one week of the pharmacy visit. PWID who were at least 18 years of age were eligible to participate. At the study appointment, research staff obtained informed consent and invited participants to complete a 45-minute Audio Computer Assisted Self Interview (ACASI) that ascertained data on a variety of topics, including socio-demographic characteristics, drug use history, HIV risk behaviors, syringe access and disposal practices, and history of access to medical and social services. Participants were compensated with $20 and a round-trip Metrocard for completion of the survey. Data collection was conducted between March 2009 and October 2010. The PHARM-Link study was approved by the institutional review boards at the New York Academy of Medicine and Columbia University. The current analyses are restricted to participants who reported injection of illicit drugs in the three months prior to interview.

Individual-level measures

High-risk injection behaviors

The outcomes in this analysis were the following high-risk injection behaviors: unsterile syringe use, receptive syringe sharing, and the acquisition of syringes from unsafe sources. Unsterile syringe use includes both receptive syringe sharing and injectors' reuse of their own syringes. This behavior was measured using the following item: "In the past three months, how often did you use a syringe that you were absolutely sure had not been used by anyone, not even yourself? By this, I mean you heard or could feel the cap "snap" when you turned the cap to remove it from the needle?" Participants were asked to respond to this item on a 6-point Likert scale ranging from "Never" to "Always." Responses were dichotomized so that participants who endorsed any option other than "Always" were considered to have engaged in unsterile syringe use. Similarly, receptive syringe sharing was measured using the following item: "In the past three months, how often did you use a syringe that you knew someone had used before you?" Participants were asked to respond to this item on a 6-point Likert scale ranging from "Never" to "Always." Responses were dichotomized so that participants who endorsed any option other than "Never" were considered to have engaged in receptive syringe sharing. Finally, to assess the acquisition of syringes from unsafe sources, participants were asked to report the frequency with which they obtained syringes from friends, relatives, syringe dealers, and shooting galleries in the past three months, using a 7-point Likert scale ranging from "Never" to "Everyday." Responses were dichotomized so that participants who reported obtaining syringes from any of these sources were categorized as having used an unsafe syringe source.

Individual-level covariates

On the basis of previous research regarding injection risk behavior among PWID, the following individual-level covariates were evaluated as potential confounders of associations between neighborhood socioeconomic disadvantage and high-risk injection behavior: age (continuous), gender (male/female), race (black/Latino/white, other), education (high school graduate, GED/less than high school), income (continuous), PHARM-Link randomization group (intervention/primary control), homelessness in the past 6 months (yes/no), sexual orientation (gay, lesbian, bisexual/heterosexual), HIV status (positive/negative or unknown), and injection frequency (daily/less than daily).

Income was measured using two items: 1) "What was your total legal income (on the books) before taxes in the past year, this includes public assistance, SSI, etc.?" and 2) "What was your total untaxable income (off the books) in the past year?" Because these items had categorical response options, the midpoint of categories selected by participants in response to each item were summed to generate a continuous estimate of total income in the past year. This approach has been used in other studies to derive continuous measures of educational attainment and income from categorical data.[148]

Neighborhood-level measures

Neighborhood socioeconomic disadvantage

Indicators of neighborhood socioeconomic disadvantage were created using census tract-level data from the 2006-2010 American Community Survey 5-year estimates. The American Community Survey (ACS) is a nationwide, continuous survey administered by the US Census Bureau to collect data on the demographic, housing, social, and economic characteristics of the US population.[149,150] To generate precise estimates of community characteristics at the census tract-level, the ACS aggregates data from five consecutive years, due to the limited population size of most census tracts (typically ~4,000).[151] Estimates are interpreted as the average value of a given characteristic over the time period during which the data were collected to produce the estimate.

Census tract-level ACS data were linked to participants in our sample using data collected on the PHARM-Link survey. Participants were asked to specify "the city and neighborhood you live in" and "the cross streets where you spend most of your time." Street intersections falling within New York City boundaries were geocoded in ArcGIS 10.1, and circular buffers with radii of 0.5 km were drawn around each intersection to approximate participants' neighborhoods. A 0.5 km-buffer, corresponding to a 10-minute walking distance, has generally been accepted as a reasonable approximation of the size of the local area to which the average neighborhood resident is exposed.[43,44,152] Because the area within these buffers included parts of multiple census tracts, census-tract level data from the ACS were used in conjunction with the area of the census tract parts within each buffer to calculate an area-weighted mean for each socioeconomic indicator. These area-weighted means were used as measures of neighborhood disadvantage for each individual in the analysis. Although many studies on the relation between

contextual factors and individual-level outcomes use census tracts as proxies for neighborhood, circular buffers centered on specific locations given by study participants may be a more meaningful way to represent local environments than administrative units whose boundaries are artificial.[115] This may be especially true in our sample, given that New York City is a densely populated metropolis in which residents are more likely to live near the boundaries of multiple census tracts.

The following neighborhood-level factors were considered as exposures of interest: percent of residents living in poverty, percent receiving public assistance, percent with low education (defined as the percent of residents >25 years of age without a high school diploma or GED), percent >16 years of age unemployed, percent residential instability (defined as the percent of residents living in a different house than 1 year ago), and an index of neighborhood deprivation. The neighborhood deprivation index was calculated using four census tract-level characteristics abstracted from the 2006-2010 ACS: percent of residents living in poverty, percent receiving public assistance, percent >16 years of age unemployed, and percent of households that are female-headed. These variables were standardized to the study sample using Z-scores and summed to calculate an index score. Positive values indicate areas with high neighborhood deprivation relative to the sample, while negative values indicate relative affluence. A score of 0 represents neighborhoods with overall values equal to the sample mean. Indices similar to this one have been used in a variety of studies to measure neighborhood socioeconomic disadvantage.[153,154]

Syringe exchange program accessibility

As a measure of SEP accessibility, distances were calculated from street intersections reported by PHARM-Link participants to the nearest authorized SEP site. A list of authorized SEP sites operating in New York City in February 2010 was obtained from the New York State Department of Health. A total of 40 SEP sites were geocoded in ArcGIS 10.1, and distances from street intersections to the nearest SEP site were calculated along the street network. Distances were measured in meters and log-transformed for inclusion in statistical analyses.

Drug-related police activity

As a measure of the intensity of drug-related police activity, the number of drug-related arrests per 1000 adult residents was calculated within community districts (named neighborhood units within New York City). Data on the number of drug-related arrests occurring among adults in New York City police precincts in 2010 were obtained from the New York State Division of Criminal Justice Services. Arrests were included if the most serious charge was a misdemeanor or felony offense for the possession, sale, or use of illicit drugs, drug paraphernalia, or a controlled substance. Census tract-level data from the 2010 US Decennial Census were used to calculate the adult population aged ≥ 16 in each police precinct. Census tract-level population data were aggregated to the precinct level according to the proportion of each census tract's surface area that lay within each police precinct. Precinct-level arrest rates per 1000 adult residents were calculated by dividing the number of drug-related arrests within each precinct by the precinct population and multiplying by 1000. Area-weighted means were used to aggregate precinct-level arrest rates to the community district level.

Analytic sample

A total of 592 participants completed the PHARM-Link survey. Of these, 61 reported insufficient data for geocoding (10.3%), 54 were missing data on one or more individual-level covariates (9.1%), and 1 was missing data on high-risk injection behavior (0.2%). Our final analytic sample contained 484 participants, or 81.7% of the original sample. Participants excluded for missing data were similar to the analytic sample with two exceptions. Excluded participants were younger than those included in the analysis and more likely to report their sexual orientation as gay, lesbian, or bisexual.

Statistical analysis

Because the PHARM-Link sample was pharmacy-recruited, and our research questions concern the influence of neighborhood-level factors on individual-level behaviors, there are at least two ways in which our sample can be considered nested: 1) by pharmacy and 2) by neighborhood. Psuedo-intraclass correlation coefficients (ICCs) were used to determine the proportion of variation in our outcomes that was explained at the pharmacy and neighborhood levels. For these analyses, community districts were used as proxies for neighborhood.

Associations between neighborhood socioeconomic disadvantage and high-risk injection behavior were measured using Poisson regression with robust error variance. These models were chosen to account for the high prevalence of outcomes in our analytic sample (23%-49%). Because odds ratios do not approximate risk ratios in the setting of common outcomes, Poisson regression was used to estimate risk ratios directly. Bivariable associations were estimated between all individual- and neighborhood-level covariates and high-risk injection behavior. Individual-level covariates were chosen for inclusion in multivariable analyses using a two-tiered approach. First, analyses were controlled for age, gender, race, education, and income. Second, additional individual-level covariates that were associated with any high-risk injection behavior at the $p<0.10$ level in bivariable analyses were added to adjusted models. Final models were adjusted for age, gender, race, education, income, homelessness, sexual orientation, and injection frequency. Measures of neighborhood socioeconomic disadvantage were entered into adjusted models of high-risk injection behavior separately and in continuous form.

Log of distance to the nearest SEP and drug-related arrest rates were evaluated as potential modifiers of associations between neighborhood socioeconomic disadvantage and high-risk injection behavior. Effect modification was assessed by entering cross-product terms for measures of neighborhood disadvantage and effect modifiers into adjusted models of high-risk injection behavior. Both log of distance to the nearest SEP and drug-related arrest rates were entered into models in continuous form. Additional analyses were carried out to determine whether these variables mediated associations between neighborhood disadvantage and high-risk injection behavior. Detailed methods describing these analyses are provided in Appendix C. All analyses were conducted in SAS 9.3.

RESULTS

Sample characteristics

Table 3.1 describes individual-level characteristics of PHARM-Link participants included in this analysis. Characteristics are given for the full sample and stratified by neighborhood socioeconomic disadvantage, where high and low groups were created by dichotomizing the neighborhood deprivation index at the median. Participants were 73.1% male with a mean age of 43.5 years. The racial/ethnic composition of the sample differed between neighborhoods of high and low disadvantage. In low

disadvantage neighborhoods, the proportions of Latino (35.1%), black (33.9%), and white (31.0%) participants were approximately equal, while in high disadvantage neighborhoods, the sample was predominantly Latino (68.6%), with smaller numbers of blacks (19.4%) and whites (12.0%). Individuals from low disadvantage neighborhoods were more likely to report both receptive syringe sharing (26.5% vs. 18.6%) and unsterile syringe use (52.1% vs. 46.3%) in the past three months, whereas use of an unsafe syringe source was nearly equal across low and high disadvantage groups (27.7% vs. 27.3%).

Table 3.2 describes measures of neighborhood socioeconomic disadvantage, SEP accessibility, and drug-related police activity for participants in the analytic sample. As described above, each of these measures was created using the street intersection at which participants reported spending most of their time. Street intersections were reported in Manhattan, Bronx, Brooklyn, and Queens. The range of socioeconomic disadvantage represented by neighborhoods surrounding these intersections was relatively wide. The proportion of residents living in poverty, for example, ranged from less than 10% to greater than 50% in the analysis sample. More than half of the study sample reported street intersections located within one kilometer of a SEP. Street intersections also tended to lie within community districts whose drug-related arrests rates were higher than the New York City average.

Table 3.3 shows correlations among the various measures of neighborhood socioeconomic disadvantage used in this analysis. All of these measures were highly positively correlated ($\rho \geq 0.60$), with the exception of percent residential instability, which was negatively correlated with the other measures.

Evaluation of pseudo-ICCs revealed that little variation in high-risk injection behavior was explained at the pharmacy and community district levels. Among pharmacies, the pseudo-ICCs for both receptive syringe sharing and use of unsafe syringe sources were zero, while that for unsterile syringe use was 0.01. Among community districts, the pseudo-ICC was zero for all high-risk injection behaviors. These findings suggest that clustering and autocorrelation of our outcomes, potentially created by the PHARM-Link recruitment scheme and by the geographic proximity of participants, were both limited.

Neighborhood socioeconomic disadvantage and high-risk injection behavior

Table 3.4 presents both unadjusted and adjusted associations between measures of neighborhood socioeconomic disadvantage and high-risk injection behavior in the past three months. In unadjusted models, the percentage of residents receiving public assistance, percentage unemployed, and neighborhood deprivation index were each independently associated with decreased receptive syringe sharing. After the addition of individual-level covariates, these associations remained statistically significant. Marginal inverse associations were also observed for the percentage of residents living in poverty (p=0.060) and percentage with low education (p=0.052) in adjusted models of receptive syringe sharing.

Although measures of neighborhood socioeconomic disadvantage were not significantly associated with unsterile syringe use in unadjusted models, the percentage of residents with low education, percentage unemployed, and neighborhood deprivation index were all associated with decreased unsterile syringe use in adjusted models. The percentage living in poverty (p=0.058) and percentage receiving public assistance (p=0.055) were also marginally associated with decreased unsterile syringe use.

No statistically significant associations were identified between measures of neighborhood socioeconomic disadvantage and the use of unsafe syringe sources.

Effect modification by SEP accessibility and drug-related police activity

Effect modification was detected between measures of neighborhood socioeconomic disadvantage and drug-related police activity in models of unsterile syringe use. When drug-related arrest rates were low (25th percentile), the percentage of residents living in poverty was associated with less unsterile syringe use (RR=0.85 per 10% increase in percent poverty). However, when drug-related arrest rates were high (75th percentile), the protective influence of percentage in poverty was attenuated, and its association with unsterile syringe use was essentially null (RR=0.98). The interaction between percentage of residents in poverty and drug-related arrests was statistically significant (p=0.0034). As shown in Figure 3.1, similar patterns were observed for the percentage receiving public assistance, percentage unemployed, and neighborhood deprivation index.

SEP accessibility was also identified as a modifier of associations between measures of neighborhood socioeconomic disadvantage and use of unsafe syringe sources. When distance to the nearest SEP was low (25th percentile), the percentage of residents living in poverty was associated with less use of unsafe syringe sources (RR=0.87 per 10% increase in percent poverty). Conversely, when distance to the nearest SEP was high (75th percentile), the association changed direction, and the percentage of residents in poverty was associated with increased use of unsafe syringe sources (RR=1.10). The cross-product term for percentage of residents in poverty and distance to the nearest SEP was statistically significant (p=0.0409). Similar patterns were observed for percentage receiving public assistance, percentage with low education, and neighborhood deprivation index, although not all interactions reached statistical significance (Figure 3.2).

Additional analyses

Both SEP accessibility and drug-related police activity were also investigated as potential mediators of relations between neighborhood socioeconomic disadvantage and high-risk injection behavior. Measures of neighborhood socioeconomic disadvantage were associated with shorter distances to the nearest SEP and higher drug-related arrest rates. However, neither of these variables was associated with high-risk injection behavior, indicating that SEP accessibility and drug-related police activity did not mediate relations between neighborhood socioeconomic disadvantage and high-risk injection behavior in our sample. Detailed results from these analyses are provided in Appendix C.

DISCUSSION

In this sample of urban PWID in New York City, neighborhood socioeconomic disadvantage was associated with safer injection behaviors. PWID in disadvantaged areas had a lower risk of receptive syringe sharing and unsterile syringe use than their counterparts in relatively better off neighborhoods. A closer examination of these results also reveals that neighborhood disadvantage was more strongly associated with receptive syringe sharing than with unsterile syringe use. Given that unsterile syringe use includes both receptive syringe sharing and reuse of one's own syringes, these findings indicate that

the inverse association between neighborhood disadvantage and unsterile syringe use was driven primarily by decreased receptive syringe sharing (as opposed to decreased syringe reuse).

Interestingly, the direction of associations among neighborhood disadvantage, receptive syringe sharing, and unsterile syringe use were contrary to what we and other authors would predict.[50,155] Hypotheses regarding the influence of neighborhood disadvantage on high-risk injection behavior commonly adhere to the premise that poverty is associated with negative health outcomes and behaviors. This association has been demonstrated in the context of numerous health conditions,[55] and has therefore, been assumed to exist for high-risk injection behavior as well. However, as opposed to finding positive associations between neighborhood disadvantage and high-risk injection behavior, our analyses found the inverse – neighborhood disadvantage was associated with a lower risk of both receptive syringe sharing and unsterile syringe use.

These results invite us to explore alternative mechanisms linking poverty to health and to contemplate how socioeconomically disadvantaged areas may decrease injection risk among PWID. One hypothesis is that disadvantaged neighborhoods may have a greater prevalence of HIV prevention services, and as a result, PWID in these areas practice safer injection behaviors. However, our finding that distance to the nearest SEP did not mediate associations between neighborhood disadvantage and high-risk injection behavior makes this explanation unlikely in our sample. Another possible explanation is injection drug use stigma. Because injection drug use is likely more common in socioeconomically disadvantaged neighborhoods, the stigma associated with this behavior may be lower in poor neighborhoods than in those that are relatively better off. Lower levels of injection drug use stigma may, in turn, lead to safer injection practices. These effects may operate through both structural and psychosocial pathways. For example, in the context of less injection drug use stigma, PWID in poor neighborhoods may face fewer barriers to accessing sterile syringes from SEPs and pharmacies. Increased syringe access may subsequently lead to decreased receptive syringe sharing. Alternatively, PWID in disadvantaged neighborhoods may experience lower levels of psychosocial stress related to their drug use, which may lead them to practice safer injection behaviors. Future research on the effects of injection drug use stigma should consider its role in mediating the influence of neighborhood disadvantage on high-risk injection behavior.

The analyses presented above also found that the protective influence of neighborhood disadvantage against unsterile syringe use was attenuated by drug-related police activity. Similar relations between neighborhood disadvantage and receptive syringe sharing were not modified by drug-related arrest rates, indicating that modification effects on unsterile syringe use were attributable to increased reuse of injectors' own syringes. Together, these results suggest that drug-related police activity is a barrier to sterile syringe access among PWID. Injectors who are deterred from acquiring new syringes at SEPs or pharmacies by a fear of police encounters may compensate for decreased syringe access by reusing their injection equipment. These findings are not surprising, given the wealth of research linking drug-related police activity to decreases in SEP attendance and increases in injection risk behavior.[69-71,73-75] However, the absence of a similar modification effect on receptive syringe sharing is unexpected. Previous studies in San Francisco and Los Angeles have specifically linked fear of arrest to increased syringe sharing.[75,156] The finding that PWID in our sample may compensate for decreased syringe access in areas with high drug-related arrest rates through syringe reuse as opposed to receptive syringe sharing may be a testament to the effectiveness of HIV prevention efforts in New York City. Although syringe reuse places PWID at risk of infections including abscesses, cellulitis, and endocarditis, it may be considered a somewhat lower risk activity than receptive syringe sharing, which facilitates the spread of BBVs, such as HIV and HCV.[2-5]

Effect modification was also detected between neighborhood socioeconomic disadvantage and distance to the nearest SEP in models of the use of unsafe syringe sources. Relations between neighborhood disadvantage and the use of unsafe syringe sources were likely null in main effect models because these associations reversed direction as distance to the nearest SEP increased (Figure 3.2). Among PWID who spent time close to an SEP site, neighborhood disadvantage was associated with decreased use of unsafe syringe sources. However, as distance to the nearest SEP site increased, neighborhood disadvantage became associated with increased use of unsafe syringe sources. These results suggest the importance of SEPs as alternatives to unsafe syringe sources. In the absence of SEPs, and therefore more restricted access to sterile syringes, neighborhood disadvantage may increase syringe acquisition from unsafe sources through a number of pathways. Disadvantaged neighborhoods may have a higher availability of syringes from unsafe sources, including syringe dealers and open drug

markets. In addition, because injection drug use is likely more common in disadvantaged neighborhoods, these areas may also contain larger, denser networks of PWID. Previous research regarding the influence of social networks on injection practices has shown that network size and density are positively associated with high-risk injection behavior.[56] Conversely, in neighborhoods containing SEPs, the protective influence of socioeconomic disadvantage, which we observed in the context of receptive syringe sharing and unsterile syringe use, was observed for the use of unsafe syringe sources as well. This result is consistent with previous work linking SEP proximity to increased SEP participation.[44,108,109]

The findings from this study should be considered in light of a number of limitations. First, our data are cross-sectional, which prevents us from establishing the causality of relations between neighborhood socioeconomic disadvantage and high-risk injection behavior. Present-day risk behaviors are likely influenced by socioeconomic contexts experienced in the past, which we are unable to capture using a cross-sectional design. This is a common limitation of analyses investigating neighborhood-level characteristics due to the difficulty of studying neighborhoods longitudinally. Second, self-reported data were used to create measures of high-risk injection behavior. Although this approach introduces the possibility of bias, previous studies have shown that self-reported measures of injection risk behavior are accurate and reliable.[157] Third, our measures of SEP accessibility and drug-related police activity may have been subject to misclassification issues. Distance to the nearest SEP was calculated using the locations of New York State-registered SEP sites as of February 2010. As a result, this measure did not account for SEP sites that opened and closed during the data collection period, illegal SEP sites, or secondary syringe exchange. With regard to drug-related arrest rates, the smallest geographic units for which arrest data were available were police precincts. Measures of drug-related police activity on a smaller spatial scale may have been more appropriate for studying the influence of law enforcement on individual-level behavior. Although measures of SEP accessibility and drug-related police activity were imperfect, statistically significant interactions were identified between both of these variables and neighborhood socioeconomic disadvantage. These results indicate that both constructs were sufficiently captured by the measures used. Fourth, the findings from our study may have limited external validity. Participants in our sample were recruited while purchasing syringes from pharmacies, which suggests that they may engage in fewer high-risk injection behaviors than PWID in the general population who do

not use safe syringe sources. In addition, our study was conducted in New York City, where syringe availability is high and HIV prevention services are extensive in comparison to other parts of the US. Taken together, these circumstances indicate that the findings from our analyses are not broadly generalizable. However, the sale of non-prescription syringes has been legalized in several states, creating new populations of pharmacy-using PWID across the country. Understanding the influence of neighborhood context on patterns of risk behavior in this group will continue to be important. Furthermore, as harm reduction approaches to addressing injection drug use become more commonplace, populations of PWID in urban areas will more closely resemble those in New York City.

In this study, we sought to explore how one aspect of the neighborhood context – socioeconomic disadvantage – influences high-risk injection behavior. Our results highlight the importance of the risk environment in shaping injection behavior and BBV transmission among PWID. Not only was neighborhood-level disadvantage associated with decreased receptive syringe sharing and unsterile syringe use, but relations with unsterile syringe use and the use of unsafe syringe sources were modified by other area-level phenomena – SEP accessibility and drug-related police activity. These results have numerous implications for both research and policy. Future studies could attempt to identify characteristics of disadvantaged neighborhoods that decrease the likelihood of certain high-risk injection behaviors. Given the common perception of disadvantaged neighborhoods as high-risk environments, this is a potentially fruitful, and as yet, unexplored avenue of inquiry. In addition, new research could also examine the role of neighborhood disadvantage in shaping other behaviors that facilitate BBV transmission, such as the sharing of other injection paraphernalia (e.g. cotton, cookers, water). With respect to policy, our findings regarding effect modification provide further evidence of the benefits of SEPs and the harms of police activity in the context of injection risk behavior. Together, these results are consistent with prior recommendations that injection drug use be addressed using approaches geared toward harm reduction as opposed to law enforcement.

Overall, research on the influence of neighborhood-level factors on injection drug use is still in its nascent stages. Additional studies are needed to investigate how aspects of the risk environment and their interplay influence individual-level behavior. A better understanding of these relations will be instrumental in designing policy interventions geared toward eliminating BBV transmission among PWID.

CHAPTER 3 TABLES AND FIGURES

Table 3.1 Descriptive characteristics of PHARM-Link study participants by level of neighborhood socioeconomic disadvantage (N=484)

Characteristic	Total (N=484)	Low neighborhood disadvantage[a] (N=242)	High neighborhood disadvantage[a] (N=242)	*p*-value[b]
	No. (%) or Mean (SD)			
Age	43.5 (9.3)	43.9 (9.9)	43.1 (8.7)	0.38
Male	354 (73.1%)	178 (73.6%)	176 (72.7%)	0.84
Race/ethnicity				<.0001[c]
Hispanic/Latino (regardless of race)	251 (51.9%)	85 (35.1%)	166 (68.6%)	
Non-Hispanic Black	129 (26.7%)	82 (33.9%)	47 (19.4%)	
Non-Hispanic White and other	104 (21.5%)	75 (31.0%)	29 (12.0%)	
Less than high school diploma/GED	179 (37.0%)	86 (35.5%)	93 (38.4%)	0.51
Income in the past year	8951 (10412)	9556 (11219)	8347 (9522)	0.20
Homeless in the past 6 months	162 (33.5%)	88 (36.4%)	74 (30.6%)	0.18
Gay, lesbian, or bisexual	52 (10.7%)	28 (11.6%)	24 (9.9%)	0.56
Injected daily in the past 3 months	167 (34.5%)	77 (31.8%)	90 (37.2%)	0.21
HIV positive	63 (13.0%)	16 (6.6%)	47 (19.6%)	<.0001[c]
PHARM-Link intervention group	225 (46.5%)	130 (53.7%)	95 (39.3%)	0.0014[c]
High-risk injection behaviors (in the past 3 months)				
Receptive syringe sharing	109 (22.5%)	64 (26.5%)	45 (18.6%)	0.04[c]
Unsterile syringe use	238 (49.2%)	126 (52.1%)	112 (46.3%)	0.20
Use of unsafe syringe source	133 (27.5%)	67 (27.7%)	66 (27.3%)	0.92

[a] Low and high neighborhood disadvantage groups were created by dichotomizing the neighborhood deprivation index at the median. Low neighborhood disadvantage = neighborhood deprivation index < 0.3, High neighborhood disadvantage = neighborhood deprivation index ≥ 0.3.

[b] *p*-value for comparison of low and high neighborhood disadvantage groups. *p*-values are from t-tests for continuous variables and Chi-square tests for categorical variables.

[c] $p < 0.05$

Table 3.2 Characteristics of geographic areas surrounding street intersections reported by PHARM-Link study participants (N=484)

Characteristic	Mean (SD)	Minimum	25th percentile	50th percentile	75th percentile	Maximum
Neighborhood socioeconomic disadvantage						
% poverty	31.3 (10.0)	4.0	26.2	30.3	40.0	50.7
% public assistance	8.0 (3.9)	0.2	5.4	7.4	11.3	15.5
% low education	30.9 (12.0)	1.8	21.4	33.3	40.7	51.0
% unemployed	12.7 (4.2)	3.4	9.7	12.8	15.6	21.5
% residential instability	12.7 (4.9)	3.9	9.4	11.8	14.8	32.6
Neighborhood deprivation index	0.1 (3.7)	-9.2	-2.1	0.3	2.7	7.3
Distance to the nearest SEP (m)	1161 (1153)	5	413	861	1423	8233
Log of distance to the nearest SEP	6.7 (1.0)	1.6	6.0	6.8	7.3	9.0
Drug-related arrests per 1000 adults	34.9 (16.6)	1.1	26.7	38.2	49.0	64.6

Table 3.3 Correlations among indicators of neighborhood socioeconomic disadvantage measured for PHARM-Link participants (N=484)

	% poverty	% public assistance	% low education	% unemployed	% residential instability	Neighborhood deprivation index
% poverty	1					
% public assistance	0.90	1				
% low education	0.79	0.81	1			
% unemployed	0.75	0.73	0.60	1		
% residential instability	-0.34	-0.33	-0.29	-0.21	1	
Neighborhood deprivation index	0.95	0.95	0.80	0.87	-0.37	1

Table 3.4 Unadjusted and adjusted associations between indicators of neighborhood socioeconomic disadvantage and high-risk injection behavior among PHARM-Link study participants (N=484)

	Receptive syringe sharing		**Unsterile syringe use**		**Use of unsafe syringe source**	
	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
% poverty	0.86 (0.73, 1.02)	0.84 (0.70, 1.01)	0.93 (0.85, 1.01)	0.91 (0.83, 1.00)	0.97 (0.85, 1.11)	0.98 (0.84, 1.14)
% public assistance	0.60 (0.40, 0.90)[a]	0.56 (0.36, 0.88)[a]	0.81 (0.65, 1.02)	0.78 (0.61, 1.00)	0.88 (0.62, 1.25)	0.91 (0.63, 1.32)
% low education	0.89 (0.78, 1.02)	0.87 (0.75, 1.00)	0.94 (0.87, 1.01)	0.92 (0.85, 0.98)[a]	0.98 (0.87, 1.11)	0.99 (0.86, 1.13)
% unemployed	0.62 (0.41, 0.93)[a]	0.56 (0.37, 0.86)[a]	0.81 (0.65, 1.01)	0.79 (0.63, 0.99)[a]	0.84 (0.60, 1.17)	0.77 (0.53, 1.10)
% residential instability	0.98 (0.69, 1.41)	0.96 (0.67, 1.38)	1.01 (0.84, 1.22)	1.02 (0.85, 1.23)	0.96 (0.70, 1.32)	0.94 (0.69, 1.29)
Neighborhood deprivation index	0.82 (0.69, 0.98)[a]	0.79 (0.65, 0.96)[a]	0.91 (0.83, 1.01)	0.89 (0.81, 0.99)[a]	0.94 (0.81, 1.09)	0.93 (0.79, 1.10)

[a] $p < 0.05$

Note: Values shown are risk ratios and 95% confidence intervals for 10% increases (e.g. 10% to 20%) in indicators of neighborhood socioeconomic disadvantage, with the exception of neighborhood deprivation index. For neighborhood deprivation index, risk ratios were estimated for 4-unit increases. Adjusted models were controlled for the following individual-level confounders: age, gender, race, education, income, homelessness, sexual orientation, and injection frequency.

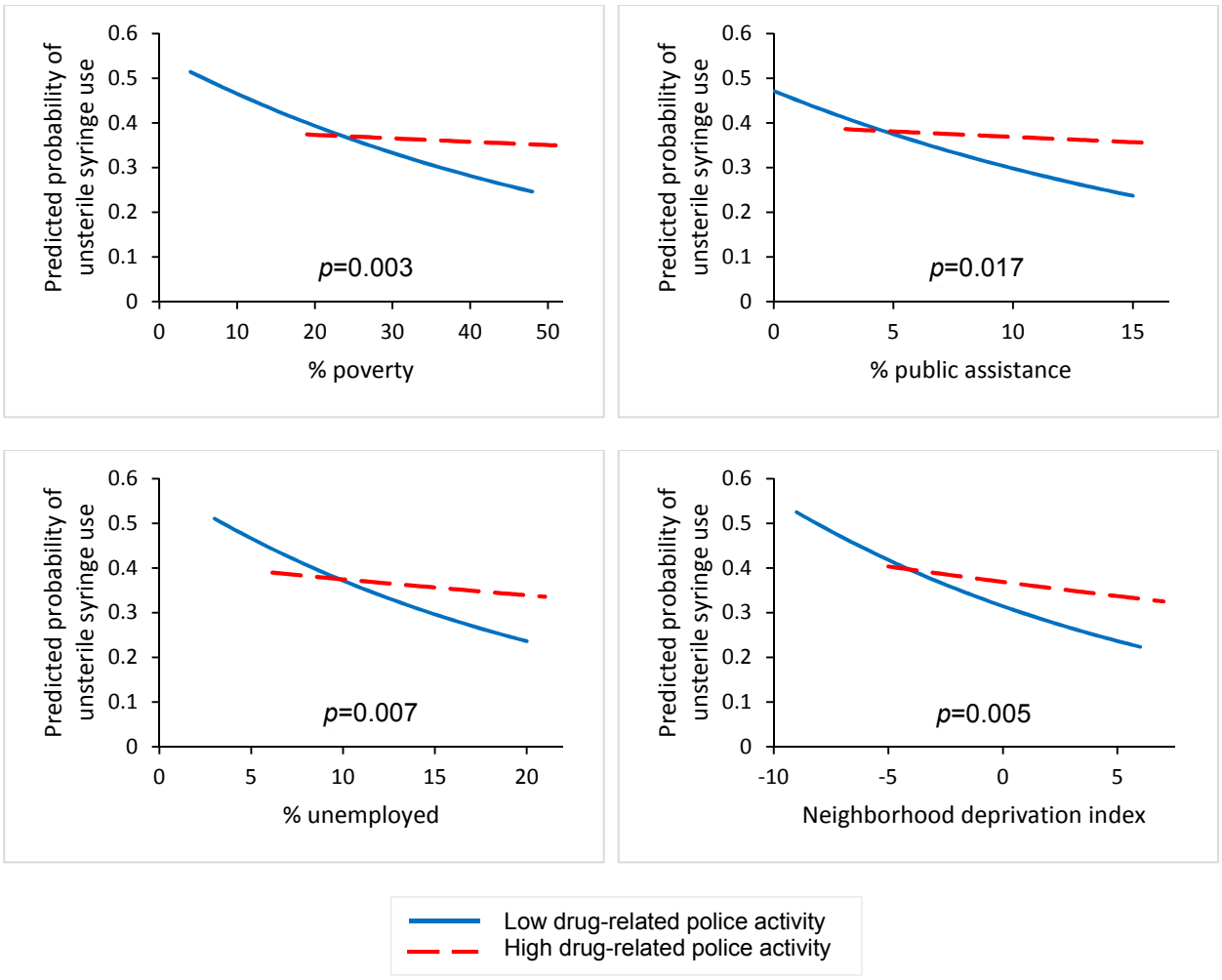


Figure 3.1. Effect modification of associations between indicators of neighborhood socioeconomic disadvantage and unsterile syringe use by drug-related police activity. Predicted probabilities of unsterile syringe use were estimated when drug-related arrest rates per 1000 adults were fixed at the 25th percentile (low drug-related police activity) and the 75th percentile (high drug-related police activity). Models were adjusted for the following individual-level confounders: age, gender, race, education, income, homelessness, sexual orientation, and injection frequency. Interaction *p*-values are from significance tests of cross-product terms entered into adjusted models.

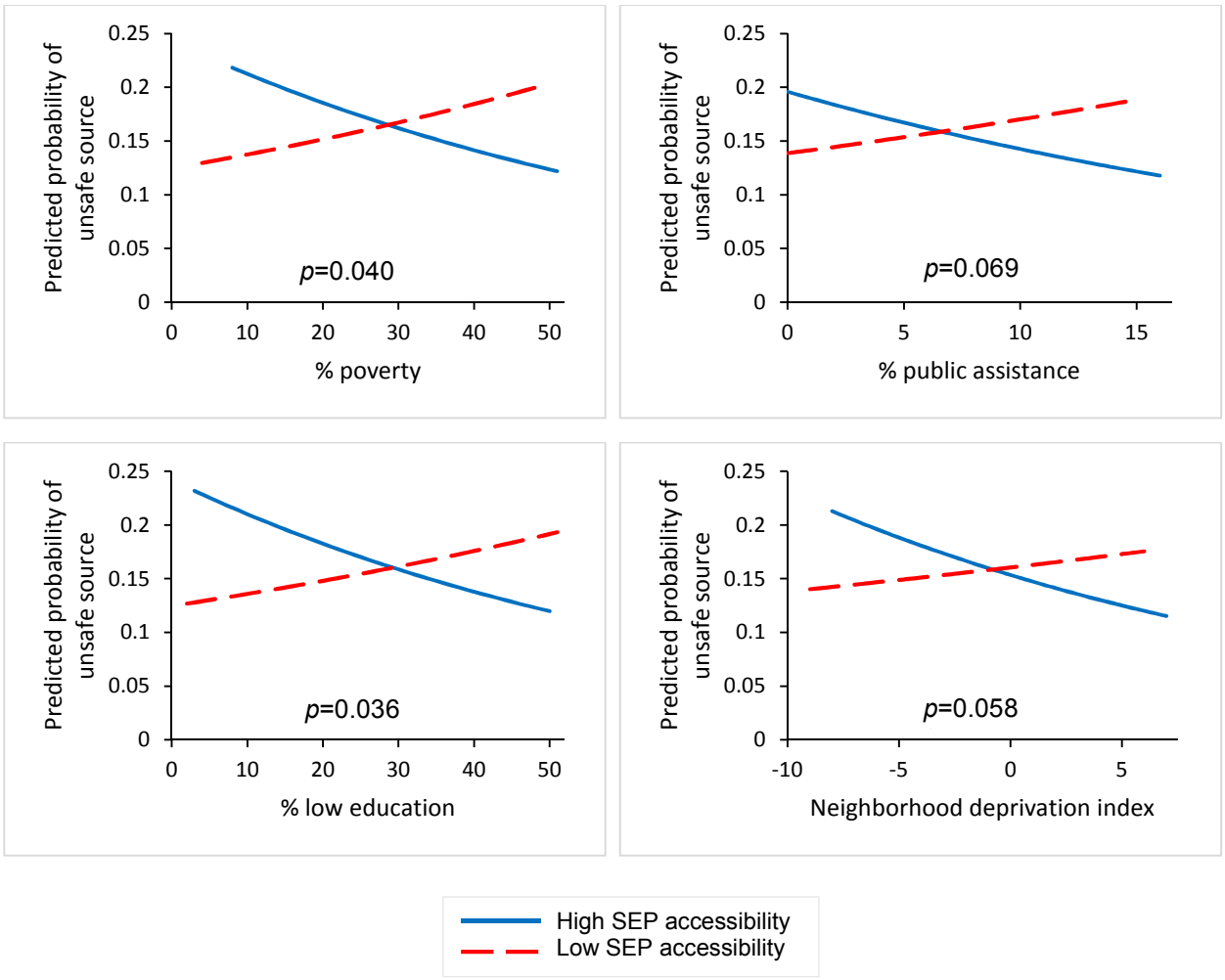


Figure 3.2. Effect modification of associations between indicators of neighborhood socioeconomic disadvantage and the use of unsafe syringe sources by SEP accessibility. Predicted probabilities of the use of unsafe syringe sources were estimated when distance to the nearest SEP was fixed at the 25th percentile (high SEP accessibility) and the 75th percentile (low SEP accessibility). Models were adjusted for the following individual-level confounders: age, gender, race, education, income, homelessness, sexual orientation, and injection frequency. Interaction *p*-values are from significance tests of cross-product terms entered into adjusted models.

CHAPTER 4: The influence of social discomfort surrounding the acquisition of sterile syringes on high-risk injection behavior among people who inject drugs

INTRODUCTION

In an effort to increase sterile syringe access among people who inject drugs (PWID), many US states have legalized both syringe exchange programs (SEPs) and the sale of non-prescription syringes from pharmacies. However, despite these interventions, PWID continue to practice injection behaviors that increase their risk of acquiring blood borne viruses (BBVs). In 2012, an estimated 30% of HIV-negative PWID engaged in receptive syringe sharing, while 55% used contaminated injection equipment.[7] Identifying facilitators and barriers to the utilization of safe syringe sources is necessary to reduce high-risk injection behavior and to eliminate the transmission of BBVs among PWID.

One potential obstacle to sterile syringe access among PWID is the lack of comfort that many injectors experience when entering SEPs and pharmacies to acquire syringes. Pharmacies, in particular, have emerged as intimidating environments for PWID to navigate.[61,62,76-78] Injectors have reported a fear of being identified as PWID by pharmacy staff, and being treated poorly as a result.[79,80] Both unfriendly attitudes and judgmental treatment on the part of pharmacists and other patrons have been cited as obstacles to pharmacy syringe purchases.[62,77,81] In addition, some pharmacists may refuse to sell syringes to PWID or question them about the intended use of syringes.[61,76,79,82] Feelings of discomfort may be exacerbated by injectors' fear that pharmacy staff and patrons who become aware of their injection drug use may share this information with other members of the community.[76,78,81] Although PWID have expressed similar concerns surrounding the use of SEPs,[65,78,83] experiences with SEP staff are often described in positive terms.[61,76,84] Qualitative data indicate that SEP staff make their clients feel as though they are acknowledged and that they have value.[84]

The lack of comfort reported by PWID during visits to SEPs and pharmacies (hereafter referred to as *social discomfort*) may be attributable to injection drug use stigma.[76-78] Negative attitudes toward drug use and drug injection are widespread in today's society, making PWID a highly stigmatized population. The social discomfort experienced by members of this group as a consequence of injection drug use stigma may discourage them from frequenting safe syringe sources to acquire sterile injection equipment. As a result, they may be more likely to engage in high-risk injection behaviors, such as receptive syringe sharing, syringe reuse, and the acquisition of syringes from unsafe sources. No studies, of which we are aware, have investigated associations between social discomfort and high-risk injection behavior.

However, previous work supports the existence of a relation between these constructs. Among a sample of PWID in Chennai, India, Latkin and colleagues found that drug use stigma was associated with increased syringe sharing.[89] One explanation for these findings is that social discomfort brought about by drug use stigma posed a barrier to sterile syringe access. In addition, among a sample of PWID in New York City, Rivera and colleagues found that higher levels of injection drug use stigma were associated with not acquiring syringes from either SEPs or pharmacies in the past three months.[143] Again, social discomfort is a potential mediator of this association. Further studies have shown that stigma is a powerful barrier to accessing health services in the setting of several health conditions, including HIV,[91] depression,[144] and obesity.[145]

Because social discomfort is likely a product of social interactions, its influence on high-risk injection behavior may also vary by social context. Given the concentration of drug markets and PWID in poor areas, it may be meaningful to consider whether social discomfort operates differentially in neighborhoods with varying levels of socioeconomic disadvantage. Disadvantaged neighborhoods may be characterized by higher levels of drug-related police activity, greater availability of syringes from unsafe sources, and larger, denser networks of PWID. Together, these attributes may enhance the negative influence of social discomfort on high-risk injection behavior. However, it is also possible that disadvantage has the reverse effect. In poor neighborhoods, where injection drug use may be more common, PWID may be less stigmatized. Injectors in disadvantaged areas may experience greater social support in the community, which may serve to buffer increases in high-risk injection behavior brought about by social discomfort.

In this study, we sought to investigate the influence of social discomfort on high-risk injection behavior by measuring associations between these constructs among a sample of PWID in New York City. Furthermore, we examined whether associations between measures of social discomfort and high-risk injection behavior were modified by neighborhood socioeconomic disadvantage.

METHODS

Subjects and setting

The current analyses use data from the Pharmacists as Resources Making Links to Community Services (PHARM-Link) study, which has been described elsewhere.[147] Briefly, the PHARM-Link study is a pharmacy-randomized intervention trial designed to evaluate the impact of pharmacy-delivered health and social service referrals on a variety of outcomes among pharmacy staff and PWID. Previous studies have shown that, in addition to distributing sterile syringes, SEPs are instrumental in linking PWID to health and social services, such as HIV testing and drug treatment. The purpose of PHARM-Link was to evaluate the extension of this public health role to pharmacies.

Pharmacies in high drug activity neighborhoods in New York City, which were registered to sell sterile syringes through New York State's Expanded Syringe Access Program (ESAP), were invited to participate in the study. A total of 71 pharmacies were randomized to intervention and primary control arms in roughly equal numbers. Intervention pharmacies offered PWID referrals to health and social services via print materials and a drug user-specific web resource guide, while primary control pharmacies offered only standard syringe sales services. PWID were recruited into PHARM-Link when visiting study pharmacies to purchase nonprescription syringes. During syringe transactions with PWID, pharmacy staff were trained to discreetly describe the PHARM-Link study and to offer a study appointment with research staff within one week of the pharmacy visit. PWID who were at least 18 years of age were eligible to participate. At the study appointment, PWID were invited to complete a 45-minute Audio Computer Assisted Self Interview (ACASI) that ascertained data on a variety of topics, including socio-demographic characteristics, drug use history, HIV risk behaviors, syringe access and disposal practices, and history of access to medical and social services. Participants were compensated with $20 and a round-trip Metrocard for completion of the survey. Data collection was conducted between March 2009 and October 2010. The PHARM-Link study was approved by the institutional review boards at the New York Academy of Medicine and Columbia University. The current analyses are restricted to participants who reported injection of illicit drugs in the three months prior to interview.

Measures

High-risk injection behaviors

The outcomes in this analysis were the following high-risk injection behaviors: unsterile syringe use, receptive syringe sharing, and the acquisition of syringes from unsafe sources. Unsterile syringe use includes both receptive syringe sharing and injectors' reuse of their own syringes. This behavior was measured using the following item: "In the past three months, how often did you use a syringe that you were absolutely sure had not been used by anyone, not even yourself? By this, I mean you heard or could feel the cap "snap" when you turned the cap to remove it from the needle?" Participants were asked to respond to this item on a 6-point Likert scale ranging from "Never" to "Always." Responses were dichotomized so that participants who endorsed any option other than "Always" were considered to have engaged in unsterile syringe use. Similarly, receptive syringe sharing was measured using the following item: "In the past three months, how often did you use a syringe that you knew someone had used before you?" Participants were asked to respond to this item on a 6-point Likert scale ranging from "Never" to "Always." Responses were dichotomized so that participants who endorsed any option other than "Never" were considered to have engaged in receptive syringe sharing. Finally, to assess the acquisition of syringes from unsafe sources, participants were asked to report the frequency with which they obtained syringes from friends, relatives, syringe dealers, and shooting galleries in the past three months, using a 7-point Likert scale ranging from "Never" to "Everyday." Responses were dichotomized so that participants who reported obtaining syringes from any of these sources were categorized as having used an unsafe syringe source.

Social discomfort surrounding the acquisition of sterile syringes

Social discomfort surrounding the acquisition of sterile syringes from pharmacies and SEPs was measured using five items from the PHARM-Link survey. Participants were asked to indicate their level of agreement with the following items on a 4-point Likert scale ranging from "Strongly agree" to "Strongly disagree": 1) It doesn't matter to me if people know why I'm buying syringes when I'm in line at the pharmacy, 2) I feel comfortable trying to buy a syringe at any pharmacy even if I don't know if they'll sell to me before I go in the store, 3) It wouldn't matter to me if people saw me walk into a syringe exchange program, 4) Pharmacists care about my health and well-being, and 5) The staff at syringe exchange programs seems to care about my health and well-being. The response format for each of these items

was recoded to a numeric scale ranging from 0 to 3, where higher scores were indicative of greater disagreement with the items, and therefore, greater social discomfort. These items were entered into analyses individually as continuous variables.

In addition to examining each item individually, the scores from the first three items listed above were combined in a simple sum to create a social discomfort score (range: 0-9). Although exploratory factor analyses revealed that all five items loaded onto a single factor, the items pertaining to pharmacists and SEP staff may reflect a different dimension of social discomfort, and for this reason, were not included in the sum score. Exploratory factor analyses limited to the first three items showed that they loaded strongly on a single factor, with loadings >0.60 for each item. The social discomfort score was entered into analyses as a continuous variable (α=0.62).

Neighborhood socioeconomic disadvantage

Neighborhood socioeconomic disadvantage was measured using an index comprised of four census tract-level characteristics: percent of residents living in poverty, percent receiving public assistance, percent >16 years of age unemployed, and percent of households that are female-headed. Census tract-level data were abstracted from the 2006-2010 American Community Survey 5-year estimates. The American Community Survey (ACS) is a nationwide, continuous survey administered by the US Census Bureau to collect data on the demographic, housing, social, and economic characteristics of the US population.[149,150] To generate precise estimates of community characteristics at the census tract-level, the ACS aggregates data from five consecutive years, due to the limited population size of most census tracts (typically ~4,000).[151] Estimates are interpreted as the average value of a given characteristic over the time period during which the data were collected to produce the estimate.

Census tract-level ACS data were linked to participants in our sample using items on the PHARM-Link survey. Participants were asked to specify "the city and neighborhood you live in" and "the cross streets where you spend most of your time." Street intersections falling within New York City boundaries were geocoded in ArcGIS 10.1, and circular buffers with radii of 0.5 km were drawn around each intersection to approximate participants' neighborhoods. Because the area within these buffers included parts of multiple census tracts, census-tract level data from the ACS were used in conjunction

with the area of the census tract parts within each buffer to calculate an area-weighted mean for each characteristic included in the neighborhood deprivation index. These area-weighted means were standardized to the study sample using Z-scores and summed to create an index score. Positive values indicate areas with high neighborhood deprivation relative to the sample, while negative values indicate relative affluence. A score of 0 represents neighborhoods with overall values equal to the sample mean.

Although many studies on the relation between contextual factors and individual-level outcomes use census tracts as proxies for neighborhood, circular buffers centered on specific locations given by study participants may be a more meaningful way to represent local environments than administrative units, whose boundaries are artificial.[115] Buffers with radii of 0.5 km, which we used in this study, have generally been accepted as reasonable approximations of the size of the local area to which the average neighborhood resident is exposed.[43,44,152] Indices containing census tract-level characteristics similar to those used here have also been used in a variety of studies to measure neighborhood socioeconomic context.[153,154]

Individual-level covariates

On the basis of previous research regarding injection risk behavior among PWID, the following individual-level covariates were evaluated as potential confounders of associations between social discomfort surrounding the acquisition of sterile syringes and high-risk injection behavior: age (continuous), gender (male/female), race (black/Latino/white, other), education (high school graduate, GED/less than high school), income (continuous), PHARM-Link randomization group (intervention/primary control), homelessness in the past 6 months (yes/no), sexual orientation (gay, lesbian, bisexual/heterosexual), HIV status (positive/negative or unknown), injection frequency (daily/less than daily), drug treatment in the past 3 months (yes/no), ever harassed by police at SEPs or pharmacies (yes/no), and SEP use in the past 3 months (yes/no).

Income was measured using two items: 1) “What was your total legal income (on the books) before taxes in the past year, this includes public assistance, SSI, etc.?” and 2) “What was your total untaxable income (off the books) in the past year?” Because these items had categorical response options, the midpoint of categories selected by participants in response to each item were summed to

generate a continuous estimate of total income in the past year. This approach has been used in other studies to derive continuous measures of education and income from categorical data.[148]

Analytic sample

A total of 592 participants completed the PHARM-Link survey. Of these, 61 reported insufficient data for geocoding (10.3%), 34 were missing data on a social discomfort item (5.7%), 20 were missing data on one or more individual-level covariates (3.4%), and 1 was missing data on high-risk injection behavior (0.2%). Our final analytic sample contained 484 participants, or 81.7% of the original sample. Participants excluded for missing data were similar to the analytic sample on all variables with three exceptions. Excluded participants were younger than those included in the analysis, more likely to report their sexual orientation as gay, lesbian, or bisexual, and less likely to report police harassment at SEPs or pharmacies.

Statistical analysis

Because the PHARM-Link sample was pharmacy-recruited, and our analysis examines a neighborhood-level factor as an effect modifier, there are at least two ways in which our sample can be considered nested: 1) by pharmacy and 2) by neighborhood. Psuedo-intraclass correlation coefficients were used to determine the proportion of variation in our outcomes that was explained at the pharmacy and neighborhood levels. For these analyses, community districts were used as proxies for neighborhood.

Associations between social discomfort surrounding the acquisition of sterile syringes and high-risk injection behavior were measured using Poisson regression with robust error variance. These models were chosen to account for the high prevalence of outcomes in our analytic sample (23%-49%). Because odds ratios do not approximate risk ratios in the setting of common outcomes, Poisson regression was used to estimate risk ratios directly. Bivariable associations were estimated between all individual- and neighborhood-level covariates and high-risk injection behavior. Individual-level covariates were chosen for inclusion in multivariable analyses using a two-tiered approach. First, analyses were controlled for age, gender, race, education, and income. Second, additional individual-level covariates

that were associated with any high-risk injection behavior at the p<0.10 level in bivariable analyses were added to adjusted models. Final models were adjusted for age, gender, race, education, income, homelessness, sexual orientation, injection frequency, and ever harassed by police at SEPs or pharmacies.

Neighborhood socioeconomic disadvantage was evaluated as a potential modifier of associations between social discomfort and high-risk injection behavior. Effect modification was assessed by entering cross-product terms for social discomfort items and the neighborhood deprivation index into adjusted models of high-risk injection behavior. Cross-product terms were assessed for statistical significance; however, because our analyses were underpowered to detect interactions, cross-product terms were deemed significant when $p<0.10$. This cut-point has been used in several other observational studies seeking to identify social determinants of health outcomes.[48,158-160] Neighborhood deprivation index was entered into models in continuous form. All analyses were conducted in SAS 9.3.

RESULTS

Sample characteristics

Table 4.1 provides descriptive statistics of PHARM-Link participants included in this analysis. Characteristics are given for both the full sample and stratified by social discomfort surrounding the acquisition of sterile syringes, where high and low groups were created by dichotomizing the social discomfort score at the median. Participants were 73.1% male with a mean age of 43.5 years. The sample was 51.9% Latino, 26.7% black, and 21.5% white. Reports of high-risk injection behavior in the past three months were relatively common, with 22.5% of participants reporting receptive syringe sharing, 49.2% reporting unsterile syringe use, and 27.5% reporting use of an unsafe syringe source. Levels of neighborhood socioeconomic disadvantage were similar across high and low levels of social discomfort.

Table 4.2 describes the items used to measure social discomfort in this analysis. The mean level of discomfort reported by participants was similar for all items with the exception of "The staff at syringe exchange programs seems to care about my health and well-being." For this item, the mean score was 0.85, while that of the other items ranged from 1.17 to 1.25.

Evaluation of pseudo-ICCs revealed that little variation in high-risk injection behavior was explained at the pharmacy and community district levels. Among pharmacies, the pseudo-ICCs for both receptive syringe sharing and use of unsafe syringe sources were zero, while that for unsterile syringe use was 0.01. Among community districts, the pseudo-ICC was zero for all high-risk injection behaviors. These findings suggest that clustering and autocorrelation of our outcomes, potentially created by the PHARM-Link recruitment scheme and by the geographic proximity of participants, were both limited.

Social discomfort surrounding the acquisition of sterile syringes and high-risk injection behavior

Table 4.3 presents associations between measures of social discomfort and high-risk injection behavior in the past three months. No statistically significant associations were observed between measures of social discomfort and receptive syringe sharing or unsterile syringe use in unadjusted or adjusted models. However, the following item was positively associated with the use of unsafe syringe sources in both unadjusted and adjusted analyses: "The staff at syringe exchange programs seems to care about my health and well-being." For every 1-unit increase in score on this item (indicative of greater disagreement), participants were 27% more likely to report using an unsafe syringe source, after controlling for individual-level covariates (RR=1.27, 1.05-1.52).

Effect modification by neighborhood socioeconomic disadvantage

Neighborhood socioeconomic disadvantage was identified as a modifier of the association between "Pharmacists care about my health and well-being" and receptive syringe sharing (Figure 4.1). When neighborhood socioeconomic disadvantage was low (25^{th} percentile), increasing disagreement with the item pertaining to pharmacists was associated with decreased receptive syringe sharing (RR=0.82 per 1-unit increase in item score). However, when neighborhood socioeconomic disadvantage was high (75^{th} percentile), increasing disagreement was associated with increased receptive syringe sharing (RR=1.16). The cross-product term for "Pharmacists care about my health and well-being" and neighborhood socioeconomic disadvantage was statistically significant (p=0.004).

Similarly, neighborhood socioeconomic disadvantage also modified associations between "The staff at syringe exchange programs seems to care about my health and well-being" and receptive syringe

sharing (Figure 4.1). The magnitude and direction of interaction effects were nearly identical to those observed for the item pertaining to pharmacists. Disagreement with the SEP staff item was positively associated with receptive syringe sharing when neighborhood disadvantage was high (RR=1.15) and inversely associated with receptive syringe sharing when neighborhood disadvantage was low (RR=0.86). Again, these trends were statistically significant (p=0.0793).

DISCUSSION

In this sample of urban PWID, indicators of social discomfort surrounding the acquisition of sterile syringes were not associated with high-risk injection behavior. The only exception was the item pertaining to SEP staff: "The staff at syringe exchange programs seems to care about my health and well-being." Participants who disagreed with this statement were more likely to have used an unsafe syringe source in the past three months. Although this result may be a spurious finding attributable to the number of comparisons performed, it is consistent with previous qualitative work on the opinions of PWID toward SEP staff. While many PWID tend to fear being stigmatized by pharmacy staff during syringe purchases, SEP staff are often described as non-judgmental, helpful, and supportive.[64,76,78,83,84] PWID in our sample appeared to view SEP staff in a similar fashion, reporting the most positive attitudes in response to the SEP staff item (Table 4.2). Considering these findings, it is possible that those who disagreed with the SEP staff item were those who experienced the highest levels of discomfort surrounding the acquisition of sterile syringes at pharmacies and SEPs. As a result, this item may have been a stronger indicator of social discomfort than the others and was found to be associated with the use of unsafe syringe sources, while all other associations were null. Participants who disagreed with the SEP staff item may have been deterred from using safe syringe sources by social discomfort, making them more likely to seek syringes from unsafe sources.

Overall, the lack of associations observed between indicators of social discomfort and high-risk injection behavior may be explained by the manner in which our sample was recruited. PWID were invited to participate in the PHARM-Link study while visiting pharmacies to purchase sterile syringes. Given this recruitment scheme, we can make two inferences about the PWID in our sample. First, the level of social discomfort among our study participants was likely lower than that among the general

population of PWID. Injectors who enrolled in our study not only felt comfortable enough to seek syringes from safe sources, but they also felt comfortable doing so at pharmacies, which according to the qualitative literature is a particularly stigmatizing environment for PWID. Second, because study participants were recruited while accessing syringes from safe sources, levels of high-risk injection behavior are likely lower in this group than among the general population of PWID. Taken together, these inferences suggest that our study sample may be missing PWID who practice high-risk injection behaviors and who have high levels of social discomfort surrounding the acquisition of sterile syringes. The absence of these PWID from our sample would have biased associations between social discomfort and high-risk injection behavior toward the null. Future studies on this topic should use community-recruited samples of PWID that include injectors who do not use safe syringe sources or who do so infrequently. Because we are interested in understanding whether social discomfort is a barrier to sterile syringe access, this approach may enhance the likelihood of identifying links between social discomfort and high-risk injection behavior.

Evaluation of neighborhood socioeconomic disadvantage as a potential modifier of relations between social discomfort and high-risk injection behavior returned a number of intriguing results. Effect modification was detected in models of receptive syringe sharing for the following items: “Pharmacists care about my health and well-being” and “The staff at syringe exchange programs seems to care about my health and well-being.” Interestingly, the magnitude and direction of interaction effects across these items was nearly identical. Among participants in high disadvantage neighborhoods, disagreement with the items pertaining to pharmacists and SEP staff was associated with increased receptive syringe sharing. This finding is consistent with our hypothesis that the fear of being mistreated at safe syringe sources may deter PWID from using them, increasing the likelihood of high-risk injection behavior. However, among participants in low disadvantage neighborhoods, the direction of the association was contrary to what we would expect. Participants who disagreed with the items pertaining to pharmacists and SEP staff were less likely to report receptive syringe sharing. One explanation for this finding is related to injection drug use stigma. Because injection drug use may be less common in low disadvantage neighborhoods, it may also be more heavily stigmatized. Consequently, PWID in low disadvantage neighborhoods may be more susceptible to social isolation as a result of their injection drug

use. Injectors who feel that pharmacists and SEP staff do not care about their health and well-being may be socially isolated from their communities – not only from non-drug users, but from other PWID as well. For this reason, they may be less likely to interact with other PWID, decreasing their risk of receptive syringe sharing.

The findings from our study should be considered in light of a number of limitations. First, the data used in these analyses are cross-sectional, which prevents us from establishing the temporality of relations between social discomfort and high-risk injection behavior. Longitudinal analyses are required to better understand the effects of social discomfort. Second, outcome data on high-risk injection behavior were self-reported by participants. Although this approach to data collection raises the possibility of bias, previous studies have shown that self-reported measures of injection risk behavior are accurate and reliable.[157] Third, we cannot be certain of the validity of our measures of social discomfort. Research on the influence of this construct has been primarily qualitative in nature, and as far as we are aware, no psychometrically tested scales have been developed to measure it. Although we used items that appear to pertain to social discomfort in the current analyses, it is possible that these items are correlated with a different construct altogether. Despite this lack of certainty, however, we remain confident that our items captured the intended construct. Factor analyses revealed that social discomfort items were related to one another, and relative levels of discomfort roughly approximated patterns observed in the qualitative literature (i.e. participants expressed the most positive attitudes toward SEP staff). While further studies are needed to develop more comprehensive and reliable scales measuring social discomfort, this gap in the research should not delay efforts to investigate a potential barrier to sterile syringe access. Fourth, the findings from our study may have limited external validity. As described above, the participants in our sample were recruited from pharmacies, and may not reflect patterns of social discomfort and high-risk injection behavior present in the general population of PWID. Pharmacies that participated in PHARM-Link may have been staffed by employees who were especially supportive of offering extended services to PWID, which may have lowered levels of social discomfort in our sample. Coupled with the lower injection risk profile of pharmacy-recruited PWID, this represents another pathway through which our findings may have been biased toward the null. Finally, our study was conducted in New York City, where syringe availability is high and HIV prevention services are

extensive in comparison to other parts of the US. Taken together, these circumstances indicate that the findings from our analyses are not broadly generalizable. However, the sale of non-prescription syringes has been legalized in several states, creating new populations of pharmacy-using PWID across the country. Understanding barriers to syringe access and patterns of risk behavior in this group will continue to be important. Furthermore, as harm reduction approaches to addressing injection drug use become more commonplace, populations of PWID in urban areas will more closely resemble those in New York City.

To our knowledge, this is the first quantitative analysis to investigate the relation between social discomfort surrounding the acquisition of sterile syringes and high-risk injection behavior. The influence of injection drug use stigma on risk behavior among PWID has been understudied in the literature, and our analyses offer important insights regarding one of the mechanisms through which it may operate. In addition, our data afforded us the opportunity to explore how the effects of social discomfort, a psychosocial construct, may be modified by neighborhood context – another area in which research has been sorely lacking. Although we did not detect associations between measures of social discomfort and high-risk injection behavior, our findings suggest the need for additional research on a variety of topics. Scales measuring injection drug use stigma and social discomfort should be developed to facilitate the investigation of these phenomena. Alternative mechanisms linking injection drug use stigma and high-risk injection behavior should be identified to improve our understanding of how this construct shapes outcomes. Studies focusing on PWID who do not use safe syringe sources should be conducted to identify barriers to syringe access in this group. Finally, given the importance of neighborhood in determining risk behavior among PWID, future studies should continue to explore the interplay of psychosocial and neighborhood constructs. Despite the availability of syringes from both SEPs and pharmacies, PWID continue to face challenges accessing sterile injection equipment from safe, legal sources. Identifying factors in the risk environment that increase the likelihood of high-risk injection behavior is critical to preventing the spread of BBVs in this population.

CHAPTER 4 TABLES AND FIGURES

Table 4.1 Descriptive characteristics of PHARM-Link study participants by level of social discomfort (N=484)

Characteristic	Total (N=484)	Low social discomfort[a] (N=238)	High social discomfort[a] (N=246)	*p*-value[b]
	No. (%) or Mean (SD)			
Age	43.5 (9.3)	43.2 (9.7)	43.8 (8.9)	0.47
Male	354 (73.1%)	176 (74.0%)	178 (72.4%)	0.69
Race/ethnicity				0.89
Hispanic/Latino (regardless of race)	251 (51.9%)	121 (50.8%)	130 (52.9%)	
Non-Hispanic Black	129 (26.7%)	64 (26.9%)	65 (26.4%)	
Non-Hispanic White and other	104 (21.5%)	53 (22.3%)	51 (20.7%)	
Less than high school diploma/GED	179 (37.0%)	93 (39.1%)	86 (35.0%)	0.35
Income in the past year	8951 (10412)	8908 (11247)	8994 (9558)	0.93
Homeless in the past 6 months	162 (33.5%)	87 (36.6%)	75 (30.5%)	0.16
Gay, lesbian, or bisexual	52 (10.7%)	33 (13.9%)	19 (7.7%)	0.03[c]
Injected daily in the past 3 months	167 (34.5%)	87 (36.6%)	80 (32.5%)	0.35
HIV positive	63 (13.0%)	29 (12.3%)	34 (13.9%)	0.61
Drug treatment in the past 3 months	367 (75.8%)	175 (74.2%)	192 (78.7%)	0.24
Ever harassed by police at SEPs or pharmacies	161 (33.3%)	86 (36.1%)	75 (30.5%)	0.19
PHARM-Link intervention group	225 (46.5%)	113 (47.5%)	112 (45.5%)	0.67
High-risk injection behaviors (in the past 3 months)				
Receptive syringe sharing	109 (22.5%)	61 (25.5%)	48 (20.0%)	0.11
Unsterile syringe use	238 (49.2%)	127 (53.4%)	111 (45.1%)	0.07
Use of unsafe syringe source	133 (27.5%)	62 (26.1%)	71 (28.9%)	0.49
Neighborhood-level characteristics				
Neighborhood deprivation index	0.1 (3.7)	-0.1 (3.8)	0.2 (3.7)	0.34

[a] Low and high social discomfort groups were created by dichotomizing the social discomfort score at the median. Low social discomfort = social discomfort score < 4, High social discomfort = social discomfort score ≥ 4.
[b] *p*-value for comparison of low and high social discomfort groups. *p*-values are from t-tests for continuous variables and Chi-square tests for categorical variables.
[c] $p < 0.05$

Table 4.2 Social discomfort items measured among PHARM-Link study participants (N=484)

Social discomfort item	Mean (SD)
I feel comfortable trying to buy a syringe at any pharmacy even if I don't know if they'll sell to me.	1.25 (0.86)
It doesn't matter to me if people know why I'm buying syringes when I'm in line at the pharmacy.	1.20 (0.98)
It wouldn't matter if people saw me walk into a syringe exchange program.	1.17 (0.89)
Pharmacists care about my health and well-being.	1.19 (0.81)
The staff at syringe exchange programs seems to care about my health and well-being.	0.85 (0.70)
Social discomfort score[b]	3.62 (2.06)

[a] PHARM-Link participants were asked to indicate their level of agreement with each social discomfort item on a 4-point Likert scale: Strongly agree=0, Agree=1, Disagree=2, Strongly disagree=3.
[b] The social discomfort score was calculated as a simple sum of participants' responses to the first three items listed in this table. This score has a range of 0-9.

Table 4.3 Unadjusted and adjusted associations between social discomfort items and high-risk injection behavior among PHARM-Link study participants (N=484)

	Receptive syringe sharing		Unsterile syringe use		Use of unsafe syringe source	
	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
I feel comfortable trying to buy a syringe at any pharmacy even if I don't know if they'll sell to me.	0.92 (0.76, 1.12)	0.97 (0.80, 1.18)	0.92 (0.82, 1.02)	0.93 (0.83, 1.04)	1.02 (0.86, 1.20)	1.07 (0.91, 1.26)
It doesn't matter to me if people know why I'm buying syringes when I'm in line at the pharmacy.	0.90 (0.75, 1.07)	0.92 (0.78, 1.09)	0.95 (0.86, 1.04)	0.96 (0.88, 1.05)	1.04 (0.90, 1.20)	1.06 (0.93, 1.22)
It wouldn't matter if people saw me walk into a syringe exchange program.	0.94 (0.78, 1.13)	0.96 (0.80, 1.15)	0.94 (0.85, 1.05)	0.96 (0.86, 1.07)	1.01 (0.86, 1.18)	0.99 (0.84, 1.16)
Pharmacists care about my health and well-being.	0.96 (0.78, 1.17)	0.96 (0.78, 1.19)	1.02 (0.91, 1.14)	1.02 (0.92, 1.15)	1.13 (0.95, 1.33)	1.11 (0.94, 1.31)
The staff at syringe exchange programs seems to care about my health and well-being.	0.97 (0.76, 1.24)	0.97 (0.77, 1.22)	1.08 (0.95, 1.22)	1.08 (0.95, 1.22)	1.28 (1.06, 1.54)[a]	1.27 (1.05, 1.52)[a]
Social discomfort score	0.95 (0.88, 1.03)	0.97 (0.90, 1.05)	0.96 (0.92, 1.01)	0.97 (0.93, 1.01)	1.01 (0.95, 1.08)	1.02 (0.96, 1.09)

[a] $p < 0.05$

Note: Values shown are risk ratios and 95% confidence intervals for 1-unit increases in social discomfort items and social discomfort score. Adjusted models were controlled for the following individual-level confounders: age, gender, race, education, income, homelessness, sexual orientation, injection frequency, and ever harassed at SEPs or pharmacies.

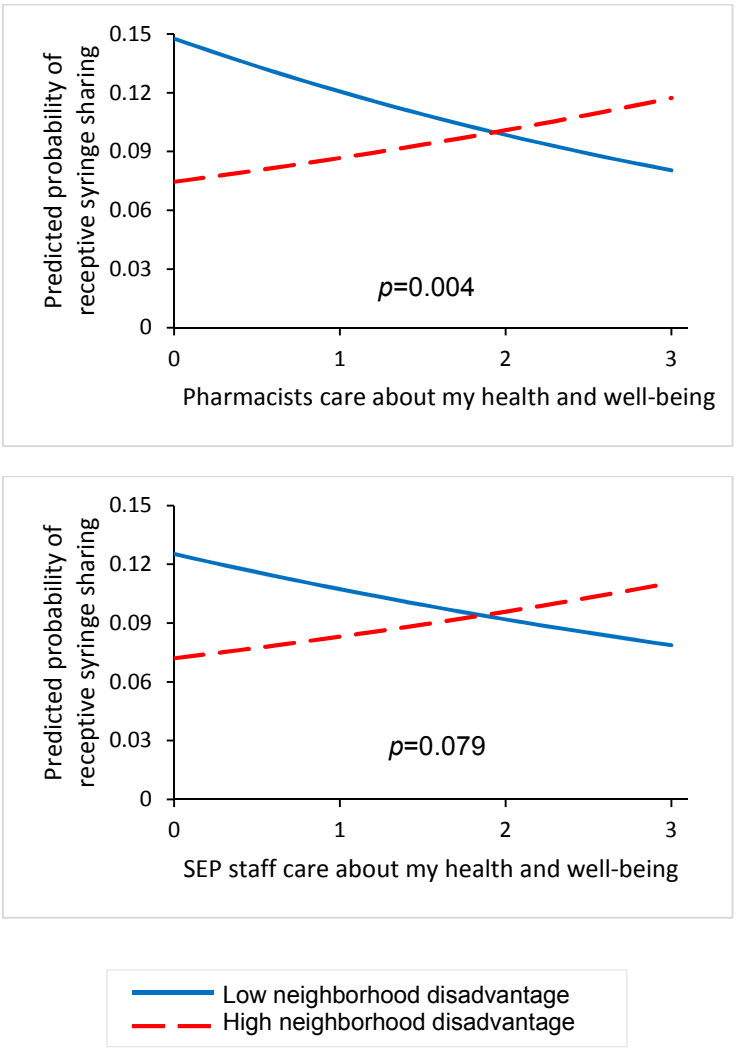


Figure 4.1. Effect modification of associations between social discomfort items and receptive syringe sharing by neighborhood disadvantage. Predicted probabilities of receptive syringe sharing were estimated when the neighborhood deprivation index was fixed at the 25th percentile (low neighborhood disadvantage) and the 75th percentile (high neighborhood disadvantage). Models were adjusted for the following individual-level confounders: age, gender, race, education, income, homelessness, sexual orientation, injection frequency, and experience of police harassment at SEPs or pharmacies. Interaction *p*-values are from significance tests of cross-product terms entered into adjusted models.

CHAPTER 5: Conclusion

Evidence gathered over the past thirty years suggests that interventions designed to motivate individual behavior change will be insufficient to eliminate the transmission of BBVs among PWID.[98,99] More recent studies have found that high-risk injection behavior is shaped not only by individual-level characteristics, but also by the environments in which these behaviors occur.[41-49] In an effort to deepen our understanding of how contextual factors influence high-risk injection behavior, this dissertation examined two understudied elements of the risk environment – neighborhood context and the social discomfort experienced by PWID when acquiring syringes at SEPs and pharmacies.

A systematic review of the literature regarding the influence of neighborhood context on injection drug use behavior was conducted to summarize and synthesize current knowledge on this relation. The findings revealed that few neighborhood-level characteristics have been evaluated as potential determinants of injection drug use behavior. Research has primarily focused on structural aspects of the neighborhood environment, such as neighborhood socioeconomic disadvantage and spatial access to pharmacies and SEPs, while social characteristics have yet to be investigated. Mediators and modifiers of relations between neighborhood-level factors and injection drug use behavior have also received little attention. Although current evidence suggests that spatial proximity to SEPs is associated with increased SEP use and decreased injection risk behavior, too few studies have been conducted on other elements of the neighborhood environment to draw definitive conclusions.

This dissertation sought to address these research gaps through a number of quantitative analyses. First, the association between neighborhood socioeconomic disadvantage and high-risk injection behavior was examined among PWID in New York City. Analyses showed that neighborhood disadvantage was associated with safer injection behaviors. PWID in disadvantaged neighborhoods were less likely to report receptive syringe sharing and unsterile syringe use than their counterparts in neighborhoods that were relatively better off. Associations between neighborhood disadvantage and decreased unsterile syringe use were attenuated by drug-related police activity, while associations between neighborhood disadvantage and the use of unsafe syringe sources were modified by SEP accessibility. In neighborhoods with high SEP accessibility, neighborhood disadvantage was associated with decreased use of unsafe syringe sources, while in neighborhoods with low SEP accessibility, neighborhood disadvantage was associated with increased use of unsafe syringe sources.

To learn more about how elements of the social environment influence risk behavior among PWID, additional analyses were performed to study the relation between social discomfort and high-risk injection behavior. In main effect models, measures of social discomfort were not associated with high-risk injection behavior, with the exception of the item pertaining to SEP staff ("The staff at syringe exchange programs seems to care about my health and well-being"). PWID who disagreed with this item were more likely to report the use of an unsafe syringe source. In addition, neighborhood socioeconomic disadvantage was investigated as a potential modifier of relations between social discomfort and high-risk injection behavior. Effect modification was observed between the items pertaining to SEP staff and pharmacists ("Pharmacists care about my health and well-being") and neighborhood socioeconomic disadvantage in models of receptive syringe sharing. In disadvantaged neighborhoods, disagreement with these items was associated with increased receptive syringe sharing, while in less disadvantaged neighborhoods, disagreement was associated with decreased receptive syringe sharing.

Together, the findings from this dissertation constitute an important contribution to our understanding of the influence of the risk environment on injection behavior among PWID. As far as I am aware, the systematic literature review included here is the first to catalogue existing studies of the relation between neighborhood context and injection drug use behavior. Not only does this review identify elements of the neighborhood environment that appear to shape behavior among injectors, but it also describes the limitations of this literature. As a result, it may serve to guide future research on the influence of neighborhood on PWID.

Analyses on the association between neighborhood socioeconomic disadvantage and high-risk injection behavior enhance our understanding of how local-area poverty may shape syringe sharing and syringe acquisition. Although similar studies have been conducted among PWID in the United States and Canada,[42,43] this dissertation likely contains the first analysis to examine the association between neighborhood disadvantage and high-risk injection behavior among PWID in New York City. As New York City contains the largest population of PWID in the United States,[14] understanding how neighborhood-level factors shape individual-level behavior in this setting is of particular importance. The results of these analyses also open new avenues of inquiry for research on the influence of neighborhood disadvantage on PWID. As mentioned above, neighborhood disadvantage was found to be associated

with safer injection behaviors. Given the tendency of many investigators to equate neighborhood disadvantage with riskier injection behaviors,[50,155] the results presented in this dissertation encourage the exploration of alternative pathways linking neighborhood poverty to injection risk behavior. In addition, the identification of interactions among neighborhood disadvantage, SEP accessibility, and drug-related police activity addresses an important gap in the literature on neighborhood and injection drug use – the dearth of studies examining modifiers of neighborhood effects. The finding that relations between neighborhood disadvantage and high-risk injection behavior were dependent on levels of SEP accessibility and drug-related police activity reinforces the importance not only of studying contextual factors, but also of their interplay in shaping risk behavior among PWID.

Finally, analyses on the association between social discomfort and high-risk injection behavior constitute the first quantitative investigation of this relation. Although no associations were detected in main effect models, this study represents an important first step toward understanding social factors that influence syringe access. To date, most research on the distribution of sterile syringes from SEPs and pharmacies has focused on whether these interventions are effective in decreasing syringe sharing and BBV transmission among PWID. This dissertation extends the literature by moving past the question of whether SEPs and pharmacy syringe sales are effective, to studying what can be done to improve their effectiveness. The investigation of interactions between social discomfort and neighborhood socioeconomic disadvantage also advances the literature by evaluating interactions between elements of the structural and social environments. Few, if any, analyses have tested similar interactions in studies of injection drug use behavior.

Although the research presented here advances our knowledge of how contextual factors may influence behaviors surrounding drug injection, these analyses are not without limitations. Cross-sectional data were used to measure associations among neighborhood socioeconomic disadvantage, social discomfort, and high-risk injection behavior, precluding the establishment of causality. This is a common limitation of neighborhoods research, given the high financial and temporal burdens associated with the collection of longitudinal data. Additionally, the PHARM-Link sample was comprised of pharmacy-recruited PWID, whose characteristics may differ from those of injectors in the general population. As discussed above, PWID who access syringes from pharmacies may have lower levels of

both social discomfort and high-risk injection behavior. Together, these characteristics may have biased associations between social discomfort and high-risk injection behavior toward the null. Although this limitation curtails our ability to draw conclusions with regard to the influence of social discomfort, non-prescription syringe laws have been passed in several states, and the targeted study of PWID who utilize pharmacy services will continue to be important. Finally, the use of a New York City sample of PWID may limit the external validity of the findings. Because syringe access and HIV prevention services are generally more extensive in New York City than in other parts of the United States, relations observed among neighborhood disadvantage, social discomfort, and high-risk injection behavior in this dissertation may not reflect those in other cities or in rural areas. However, as harm reduction interventions implemented in New York City are applied elsewhere, the similarity between our study sample and the general population of PWID in the United States will grow.

Another important limitation that was not discussed in the chapters above was the inability to study injection drug use stigma directly. The PHARM-Link survey did not include a measure of injection drug use stigma, which precluded the investigation of how stigma was related to neighborhood socioeconomic disadvantage and social discomfort. Qualitative evidence suggests that social discomfort is a product of injection drug use stigma; however, the role that stigma may play in relations between neighborhood disadvantage and high-risk injection behavior is less clear. Multiple conceptual frameworks have posited that stigma arises from differences in social, economic, and political power between groups.[161,162] Given that PWID are generally a poor, socially marginalized population, this would suggest that injection drug use stigma mediates associations between neighborhood disadvantage and high-risk injection behavior. PWID in disadvantaged neighborhoods may share more characteristics in common with other community members than their counterparts in less disadvantaged neighborhoods. As a result, levels of injection drug use stigma may be lower in disadvantaged neighborhoods, potentially leading PWID in these areas to engage in fewer high-risk injection practices. This model is consistent with our finding that neighborhood socioeconomic disadvantage was associated with decreased receptive syringe sharing and unsterile syringe use. However, it is also possible that injection drug use stigma modifies associations between neighborhood disadvantage and high-risk injection behavior. Analyses of the relation between social discomfort and high-risk injection behavior in this dissertation revealed

statistically significant interactions between specific measures of social discomfort and neighborhood disadvantage. If social discomfort is caused by injection drug use stigma, it is possible that similar interactions exist between neighborhood disadvantage and injection drug use stigma as well. Understanding the role of stigma in the production of high-risk injection behavior may be vitally important to the reduction of unsafe injection practices among PWID.

Despite the limitations of the analyses presented above, this dissertation highlights numerous directions for future research. The influence of neighborhood disadvantage on other high-risk injection behaviors should be investigated to find out whether local-area poverty influences these outcomes as well. Potential links between neighborhood disadvantage and the sharing of other injection equipment (e.g. cotton, cookers, water) are of particular interest, given their high prevalence among PWID and their role in facilitating BBV transmission.[7] Scales measuring injection drug use stigma and social discomfort should be developed to facilitate the study of these phenomena. Relations among injection drug use stigma, neighborhood socioeconomic disadvantage, and social discomfort should be investigated to enhance our understanding of how stigma influences high-risk injection behavior. Potential barriers to the use of SEPs and pharmacies should be studied among samples of PWID that include injectors who do not use safe syringe sources, or who do so infrequently. Finally, future research should investigate the potential salutary effects of disadvantaged neighborhoods.

Overall, our findings provide strong support for the importance of the risk environment in determining behavior among PWID. Not only were elements of the structural and social environments found to influence high-risk injection behavior, but specific elements of these environments were found to interact with one another to shape outcomes. Although great strides have been made toward curbing BBV transmission through the implementation of SEPs and pharmacy syringe sales, the results of this dissertation show that other aspects of the risk environment must be addressed if injection risk behavior is to be entirely eliminated.

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APPENDIX A: Description of the search strategy used for the systematic literature review

The PubMed, Web of Science, and PsycINFO databases were systematically searched for journal articles pertaining to the topic of this review. All database searches were performed on December 12, 2014. The strategies used to search each database are described in detail below.

A. PubMed search

The PubMed search was performed in two steps. In the first step, only MeSH terms were used to identify pertinent articles, while in the second step, a keyword search was performed to find articles not identified by the MeSH term search.

Step 1. The following equations of MeSH terms were entered into the PubMed search window. Results were limited to English language articles published between January 1, 1995 and December 14, 2014. Results were further restricted to those listing "Journal Article" as the document type.

Equations of MeSH terms:

A.1 – Combination of MeSH terms related to neighborhood and spatial context

"Residence Characteristics"[Mesh] OR "Spatial Analysis"[Mesh] OR "Small-Area Analysis"[Mesh] OR "Environment"[Mesh : NoExp] OR "Environment Design"[Mesh] OR "Social Environment"[Mesh]

A.2 – Combination of MeSH terms related to injection drug use behavior

"Substance Abuse, Intravenous"[Mesh]

In the "History" field of PubMed, equations A.1 and A.2 were combined with the AND operator, yielding **475** results.

Step 2. The following equations of keywords and phrases were entered into the PubMed search window. The [Title/Abstract] option was added to each keyword or phrase to restrict the results to those articles

including these words in their titles and/or abstracts. As above, results were limited to English language articles published between 1995/01/01 and 2014/12/12 and listing "Journal Article" as the document type.

Equations of keywords:

A.3 – Combination of keywords related to neighborhood and spatial context

Community[Title/Abstract] OR Neighborhood[Title/Abstract] OR Neighbourhood[Title/Abstract] OR Spatial[Title/Abstract] OR Area[Title/Abstract] OR Environment*[Title/Abstract] OR Place[Title/Abstract] OR Geographic[Title/Abstract] OR Context*[Title/Abstract]

A.4 – Combination of keywords related to injection drug use behavior

(Intravenous drug[Title/Abstract]) OR (Injecting drug[Title/Abstract]) OR (Injection drug[Title/Abstract]) OR (Inject drugs[Title/Abstract]) OR (Injectors[Title/Abstract])

In the "History" field, equations A.3 and A.4 were combined using the AND operator, yielding **2658** results.

Subsequently, the results from the MeSH term and keyword searches were combined in EndNote X7, and duplicates were removed. A total of **2971** articles were identified by the PubMed search for potential inclusion in the review.

B. Web of Science search

Because Web of Science does not use controlled vocabulary, only a keyword search was performed in this database to identify candidate articles. The Advanced Search tool was used to search the Web of Science Core Collection. Results were limited to English language publications from January 1, 1995 on. Results were further restricted to those listing "Article" as the document type. The following equations were entered into the Web of Science search window, where "TS" is indicative of a "Topic" search.

Equations of keywords:

B.1 – Combination of keywords related to neighborhood and spatial context

TS=(Community OR Neighborhood OR Neighbourhood OR Spatial OR Area OR Environment* OR Place OR Geographic OR Context*)

B.2 – Combination of keywords related to injection drug use behavior

TS=(Intravenous drug OR Injection drug OR Injecting drug OR Inject drugs OR Injectors)

In the "Search History" tab, equations B.1 and B.2 were combined using the AND operator. Results were restricted to those falling within the following Research Categories: Substance abuse, Public environmental occupational health. This search yielded **2422** articles for potential inclusion in the review.

C. PsycINFO search

The PsycINFO search was performed in two steps. In the first step, only controlled vocabulary terms were used to identify pertinent articles, while in the second step, a keyword search was performed to find articles not identified by the controlled vocabulary search.

Step 1. The following equations of controlled vocabulary terms were entered into the PsycINFO search window. Results were limited to English language articles published between January 1, 1995 and "Current." Results were further restricted to those listing "Journal" as the publication type.

Equations of controlled vocabulary terms:

C.1 – Combination of controlled vocabulary terms related to neighborhood and spatial context:

"Communities"[Explode] OR "Environment"[Do Not Explode] OR "Social Environments"[Explode]

C.2 – Combination of controlled vocabulary terms related to injection drug use behavior:

"Intravenous drug usage"[Explode]

In the “Search History” field of PsycINFO, equations C.1 and C.2 were combined with the AND operator, yielding **130** results.

Step 2. The following equations of keywords and phrases were entered into the PsycINFO search window. As above, results were limited to English language articles published from January 1, 1995 on and listing “Journal” as the publication type.

Equations of keywords:

C.3 – Combination of keywords related to neighborhood and spatial context

Community OR Neighborhood OR Neighbourhood OR Spatial OR Area OR Environment* OR Place OR Geographic OR Context*

C.4 – Combination of keywords related to injection drug use behavior

Intravenous drug OR Injecting drug OR Injection drug OR Inject drugs OR Injectors

In the “Search History” field, equations C.3 and C.4 were combined using the AND operator, yielding **1310** results.

Subsequently, the results from the controlled vocabulary and keyword searches were combined in EndNote X7, and duplicates were removed. A total of **1311** articles were identified by the PsycINFO search for potential inclusion in the review.

The final group of articles screened for the review was constructed by combining the results from the PubMed, Web of Science, and PsycINFO searches. After the removal of duplicates in EndNote X7, a total of **4578** articles were identified for potential inclusion in the review. This list was subsequently narrowed to **22** articles after screening by title, abstract, and full-text.

APPENDIX B: Detailed quantitative methods

Parent study overview: The PHARM-Link study

This dissertation utilized data collected from PWID enrolled in the Pharmacists as Resources Making Links to Community Services (PHARM-Link) study. The PHARM-Link study was a pharmacy-randomized intervention trial designed to evaluate the impact of pharmacy-delivered health and social service referrals on a variety of outcomes among pharmacy staff and PWID. Previous studies have shown that, in addition to distributing sterile syringes, SEPs are instrumental in linking PWID to health and social services, such as HIV testing and drug treatment. The purpose of PHARM-Link was to evaluate the extension of this public health role to pharmacies. Outcomes of interest among pharmacy staff included attitudes toward sterile syringe sales and enhanced pharmacy services for drug users. Among PWID, changes in access to HIV testing, primary care services, drug treatment, and health insurance were evaluated.

Eligibility, recruitment, and data collection

ESAP-registered pharmacies in high drug activity neighborhoods in New York City were invited to participate in the study. Pharmacies were eligible to participate if they met the following criteria: 1) at least one nonprescription syringe-purchasing customer per month, 2) at least one new nonprescription syringe-purchasing customer per month who became a regular customer, 3) no requirements of additional documentation from customers during syringe transactions, and 4) a willingness to sell syringes to PWID. A total of 172 pharmacies were deemed eligible for the study, of which 130 agreed to participate. Pharmacy staff were interviewed at baseline, 6-month follow-up, and 12-month follow-up. Once baseline interviews were completed, participating pharmacies were randomized to intervention, primary control, and secondary control arms. Twenty-four pharmacies dropped out of the study before randomization, and the remaining 106 pharmacies were randomized to study arms in roughly equal numbers. Intervention pharmacies offered PWID referrals to health and social services via print materials and a drug user-specific web resource guide. Primary and secondary control pharmacies only offered standard syringe sales services to PWID, which included a law-required safety insert packaged with the syringe.

PWID were recruited into PHARM-Link by pharmacy staff working in intervention and primary control pharmacies. The purpose of the secondary control arm was to evaluate intervention effects among pharmacy staff only, and therefore, was not involved in recruitment of PWID. Recruitment took place when PWID visited intervention and primary control pharmacies to purchase nonprescription syringes. During nonprescription syringe transactions with PWID, pharmacy staff were trained to discreetly describe the PHARM-Link study and to offer a study appointment with research staff within one week of the pharmacy visit. At the study appointment, research staff met with participants at the pharmacy and accompanied them to a nearby restaurant, park, or library for the purposes of data collection. After confirming participants were at least 18 years of age using photo identification, research staff obtained informed consent and invited participants to complete a 45-minute Audio Computer Assisted Self Interview (ACASI) on study laptops. The survey ascertained data on a variety of topics, including socio-demographic characteristics, drug use history, HIV risk behaviors, syringe access and disposal practices, and history of access to medical and social services. Participants who reported injection of an illicit drug in the past six months were also invited to return for a 3-month follow-up ACASI survey. Participants were compensated with $20 and a round-trip Metrocard for completion of the baseline survey and $25 for completion of the follow-up survey. Baseline data collected between March 2009 and October 2010 were combined and used to perform the analyses in this dissertation. The PHARM-Link study was approved by the institutional review boards at the New York Academy of Medicine and Columbia University.

Additional data source: 2006-2010 American Community Survey 5-year estimates

The American Community Survey (ACS) is a nationwide, continuous survey administered by the US Census Bureau to collect data on the demographic, housing, social, and economic characteristics of the US population. Each year, a total of 3 million addresses are chosen from the Census Bureau's Master Address File to participate, representing 2.5% of the US population.[149] Each household is contacted and asked to complete the survey either online or on paper.[150] For geographic areas with populations larger than 65,000, the data gathered in a single year are sufficient to generate area-level estimates of the characteristics included in the survey. However, more data are required to produce

estimates for geographic areas with smaller populations. The Census Bureau uses three years of data to calculate estimates for areas with populations as low as 20,000 and five years of data for all remaining units of census geography. Census tracts normally have populations of less than 20,000; therefore, estimates for these units are generated based on data accumulated over five consecutive years. These estimates are interpreted as the average value of a given characteristic over the time period during which the data were collected to produce the estimate. Census tract-level demographic and socioeconomic data were abstracted from the 2006-2010 ACS 5-year estimates for use in this analysis.

Individual-level measures

High-risk injection behaviors

The outcomes examined in this dissertation were the following high-risk injection behaviors reported by PWID on the PHARM-Link survey: unsterile syringe use, receptive syringe sharing, and the acquisition of syringes from unsafe sources. Unsterile syringe use includes both receptive syringe sharing and injectors' reuse of their own syringes. This behavior was measured using the following item: "In the past three months, how often did you use a syringe that you were absolutely sure had not been used by anyone, not even yourself? By this, I mean you heard or could feel the cap "snap" when you turned the cap to remove it from the needle?" Participants were asked to respond to this item on a 6-point Likert scale ranging from "Never" to "Always." Responses were dichotomized so that participants who endorsed any option other than "Always" were considered to have engaged in unsterile syringe use. Similarly, receptive syringe sharing was measured using the following item: "In the past three months, how often did you use a syringe that you knew someone had used before you?" Participants were asked to respond to this item on a 6-point Likert scale ranging from "Never" to "Always." Responses were dichotomized so that participants who endorsed any option other than "Never" were considered to have engaged in receptive syringe sharing. Finally, to assess the acquisition of syringes from unsafe sources, participants were asked to report the frequency with which they obtained syringes from friends, relatives, syringe dealers, and shooting galleries in the past three months, using a 7-point Likert scale ranging from "Never" to "Everyday." Responses were dichotomized so that participants who reported obtaining syringes from any of these sources were categorized as having used an unsafe syringe source.

Social discomfort surrounding the acquisition of sterile syringes

Social discomfort surrounding the acquisition of sterile syringes from pharmacies and SEPs was measured among PWID using five items from the PHARM-Link survey. Participants were asked to indicate their level of agreement with the following items on a 4-point Likert scale ranging from "Strongly agree" to "Strongly disagree": 1) It doesn't matter to me if people know why I'm buying syringes when I'm in line at the pharmacy, 2) I feel comfortable trying to buy a syringe at any pharmacy even if I don't know if they'll sell to me before I go in the store, 3) It wouldn't matter to me if people saw me walk into a syringe exchange program, 4) Pharmacists care about my health and well-being, and 5) The staff at syringe exchange programs seems to care about my health and well-being. The response format for each of these items was recoded to a numeric scale ranging from 0 to 3, where higher scores were indicative of greater disagreement with the items, and therefore, greater social discomfort. These items were entered into analyses individually as continuous variables.

In addition to examining each item individually, the scores from the first three items listed above were combined in a simple sum to create a social discomfort score (range: 0-9). Although exploratory factor analyses revealed that all five items loaded onto a single factor, the items pertaining to pharmacists and SEP staff may reflect a different dimension of social discomfort, and for this reason, were not included in the sum score. Exploratory factor analyses limited to the first three items showed that they loaded strongly on a single factor, with loadings >0.60 for each item. The social discomfort score was entered into analyses as a continuous variable (α=0.62). Factor analyses were performed in Mplus 6.1.

Individual-level covariates

On the basis of previous research regarding injection risk behavior among PWID, several individual-level covariates were evaluated as potential confounders of associations of interest. These data were collected through the PHARM-Link survey and included the following variables: age (continuous), gender (male/female), race (black/Latino/white, other), education (high school graduate, GED/less than high school), income (continuous), PHARM-Link randomization group (intervention/primary control), homelessness in the past 6 months (yes/no), sexual orientation (gay, lesbian,

bisexual/heterosexual), HIV status (positive/negative or unknown), injection frequency (daily/less than daily), drug treatment in the past 3 months (yes/no), ever harassed by police at SEPs or pharmacies (yes/no), and SEP use in the past 3 months (yes/no).

Income was measured using two items: 1) "What was your total legal income (on the books) before taxes in the past year, this includes public assistance, SSI, etc.?" and 2) "What was your total untaxable income (off the books) in the past year?" Because these items had categorical response options, the midpoint of categories selected by participants were summed to generate a continuous estimate of total income in the past year. This approach has been used in other studies to derive continuous measures of education and income from categorical data.[148]

Neighborhood-level measures

Neighborhood socioeconomic disadvantage

Indicators of neighborhood socioeconomic disadvantage were created using census tract-level data from the 2006-2010 American Community Survey 5-year estimates. Census tract-level ACS data were linked to participants in our sample using data collected on the PHARM-Link survey. Participants were asked to specify "the city and neighborhood you live in" and "the cross streets where you spend most of your time." Street intersections falling within New York City boundaries were geocoded in ArcGIS 10.1, and circular buffers with radii of 0.5 km were drawn around each intersection to approximate participants' neighborhoods. A 0.5 km-buffer, corresponding to a 10-minute walking distance, has generally been accepted as a reasonable approximation of the size of the local area to which the average neighborhood resident is exposed.[43,44,152] Because the area within these buffers included parts of multiple census tracts, census-tract level data from the ACS were used in conjunction with the area of the census tract parts within each buffer to calculate an area-weighted mean for each socioeconomic indicator. These area-weighted means were used as measures of neighborhood disadvantage for each individual in the analysis. Although many studies on the relation between contextual factors and individual-level outcomes use census tracts as proxies for neighborhood, circular buffers centered on specific locations given by study participants may be a more meaningful way to represent local environments than administrative units whose boundaries are artificial.[115]

The following neighborhood-level factors were considered as exposures of interest: percent of residents living in poverty, percent receiving public assistance, percent with low education (defined as the percent of residents >25 years of age without a high school diploma or GED), percent >16 years of age unemployed, percent residential instability (defined as the percent of residents living in a different house than 1 year ago), and an index of neighborhood deprivation. The neighborhood deprivation index was calculated using four census tract-level characteristics abstracted from the 2006-2010 ACS: percent of residents living in poverty, percent receiving public assistance, percent >16 years of age unemployed, and percent of households that are female-headed. These variables were standardized to the study sample using Z-scores and summed to calculate an index score. Positive values indicate areas with high neighborhood deprivation relative to the sample, while negative values indicate relative affluence. A score of 0 represents neighborhoods with overall values equal to the sample mean. Indices similar to this one have been used in a variety of studies to measure neighborhood socioeconomic disadvantage.[153,154]

Syringe exchange program accessibility

As a measure of SEP accessibility, distances were calculated from street intersections reported by PHARM-Link participants to the nearest authorized SEP site. A list of authorized SEP sites operating in New York City in February 2010 was obtained from the New York State Department of Health. A total of 40 SEP sites were geocoded in ArcGIS 10.1, and distances from street intersections to the nearest SEP site were calculated along the street network. Distances were measured in meters and log-transformed for inclusion in statistical analyses.

Drug-related police activity

As a measure of the intensity of drug-related police activity, the number of drug-related arrests per 1000 adult residents was calculated within community districts (named neighborhood units within New York City). Data on the number of drug-related arrests occurring among adults in New York City police precincts in 2010 were obtained from the New York State Division of Criminal Justice Services. Arrests were included if the most serious charge was a misdemeanor or felony offense for the possession, sale, or use of illicit drugs, drug paraphernalia, or a controlled substance. Census tract-level data from the

2010 US Decennial Census were used to calculate the adult population aged ≥ 16 in each police precinct. Census tract-level population data were aggregated to the precinct level according to the proportion of each census tract's surface area that lay within each police precinct. Precinct-level arrest rates per 1000 adult residents were calculated by dividing the number of drug-related arrests within each precinct by the precinct population and multiplying by 1000. Area-weighted means were used to aggregate precinct-level arrest rates to the community district level.

Analytic sample

A total of 592 participants completed the baseline PHARM-Link survey. Of these, 61 reported insufficient data for geocoding (10.3%), 34 were missing data on a social discomfort item (5.7%), 20 were missing data on one or more individual-level covariates (3.4%), and 1 was missing data on a high-risk injection behavior (0.2%). The final analytic sample contained 484 participants, or 81.7% of the original sample. Participants excluded for missing data were similar to the analytic sample on all variables with three exceptions. Excluded participants were younger than those included in the analysis, more likely to report their sexual orientation as gay, lesbian, or bisexual, and less likely to report police harassment at SEPs or pharmacies.

Statistical analysis

Because the PHARM-Link sample was pharmacy-recruited, and our research questions concerned the influence of neighborhood-level factors on individual-level behaviors, there were at least two ways in which our sample could be considered nested: 1) by pharmacy and 2) by neighborhood. Psuedo-intraclass correlation coefficients (ICCs) were used to determine the proportion of variation in the outcomes that was explained at the pharmacy and neighborhood levels. For these analyses, community districts were used as proxies for neighborhood.

In Chapters 3 and 4, measures of neighborhood socioeconomic disadvantage and social discomfort were evaluated as potential predictors of high-risk injection behavior. These analyses were conducted using Poisson regression with robust error variance to account for the high prevalence of outcomes in the analytic sample (23%-49%). The use of Poisson regression allowed the measurement of

associations using risk ratios as opposed to odds ratios, which do not approximate risk ratios in the setting of common outcomes. Bivariable associations were estimated between all individual- and neighborhood-level covariates and high-risk injection behavior. All multivariable analyses were adjusted for age, gender, race, education, and income. Additional individual-level covariates that were associated with any high-risk injection behavior at the $p<0.10$ level in bivariable analyses were also included in adjusted models. In analyses of the association between neighborhood socioeconomic disadvantage and high-risk injection behavior, the following individual-level covariates were tested: PHARM-Link randomization group, homelessness in the past 6 months, sexual orientation, HIV status, and injection frequency. In analyses of the association between social discomfort and high-risk injection behavior, the same group of individual-level covariates was tested, in addition to drug treatment in the past 3 months, ever harassed by police at SEPs or pharmacies, and SEP use in the past 3 months. Final models measuring associations between neighborhood socioeconomic disadvantage and high-risk injection behavior were adjusted for age, gender, race, education, income, homelessness, sexual orientation, and injection frequency. Final models of associations between social discomfort and high-risk injection behavior were adjusted for the same set of individual-level covariates, in addition to ever harassed by police at SEPs or pharmacies. Measures of neighborhood socioeconomic disadvantage and social discomfort were entered into adjusted models of high-risk injection behavior individually and in continuous form.

Additional variables were evaluated as potential effect modifiers of the associations examined in Chapters 3 and 4. Log of distance to the nearest SEP and drug-related arrest rates were evaluated as potential modifiers of the relation between neighborhood socioeconomic disadvantage and high-risk injection behavior. Similarly, neighborhood socioeconomic disadvantage was evaluated as a potential modifier of associations between social discomfort and high-risk injection behavior. Effect modification was assessed by entering cross-product terms into adjusted models of high-risk injection behavior and testing these terms for statistical significance. All potential modifiers were entered into analyses separately and in continuous form.

Supplementary analyses were performed to determine whether log of distance to the nearest SEP and drug-related arrest rates mediated associations between neighborhood socioeconomic

disadvantage and high-risk injection behavior. Detailed methods and results from these analyses are provided in Appendix C.

All statistical analyses in this dissertation were conducted in SAS 9.3.

APPENDIX C: Mediation analyses of syringe exchange program accessibility and drug-related police activity

METHODS

Syringe exchange program (SEP) accessibility and drug-related police activity were investigated as potential mediators of associations between neighborhood socioeconomic disadvantage and high-risk injection behavior. Because our sample size was insufficient to perform a formal mediation analysis, mediation was assessed through the following three-step process:

First, associations were measured between indicators of neighborhood socioeconomic disadvantage and high-risk injection behavior. The methods and results from these analyses are described in Chapter 3.

Second, analyses were performed to determine whether indicators of neighborhood socioeconomic disadvantage were associated with SEP accessibility and drug-related police activity. As explained in Chapter 3, SEP accessibility was measured using the distance between each participant's street intersection and the nearest SEP site along the street network. Distances were measured in meters and log-transformed for inclusion in analyses. Drug-related police activity was measured using drug-related arrest rates per 1000 adults, aggregated to the community-district level. Both distance to the nearest SEP and drug-related arrest rates were entered into analyses in continuous form. To measure associations between neighborhood socioeconomic disadvantage and SEP accessibility, unadjusted generalized estimating equation models were created for log of distance to the nearest SEP. Cluster robust standard errors were used to correct for autocorrelation within community district areas. Associations between indicators of neighborhood socioeconomic disadvantage and drug-related police activity were measured using Pearson correlations.

Third, analyses were performed to determine whether SEP accessibility and drug-related police activity were associated with the dichotomous indicators of high-risk injection behavior used in the main analyses – receptive syringe sharing, unsterile syringe use, and the use of unsafe syringe sources. These associations were measured using Poisson regression with robust error variance. All models were adjusted for the same set of individual-level covariates used in the main effect models in Chapter 3 – age, gender, race, education, income, homelessness, sexual orientation, and injection frequency.

The existence of statistically significant associations linking neighborhood disadvantage to high-risk injection behavior, neighborhood disadvantage to SEP accessibility (or drug-related police activity), and SEP accessibility (or drug-related police activity) to high-risk injection behavior was considered evidence of mediation.

RESULTS

Table C.1 shows regression coefficients from unadjusted GEE models measuring associations between indicators of neighborhood socioeconomic disadvantage and SEP accessibility. Increases in the percentage of neighborhood residents living in poverty, the percentage receiving public assistance, and the neighborhood deprivation index were all associated with smaller distances to the nearest SEP. Increases in the percentage unemployed was also marginally associated with closer SEP sites ($p=0.06$). Neither the percentage of residents with low education nor the percentage with residential instability were associated with SEP accessibility.

Table C.2 displays Pearson correlation coefficients for indicators of neighborhood socioeconomic disadvantage and drug-related police activity, both measured at the community district level. Statistically significant, positive correlations were observed between all indicators of disadvantage and drug-related arrest rates, with the exception of the percentage of residents with residential instability. Correlations between drug-related arrest rates and the following indicators were particularly strong ($r>0.75$): the percentage living in poverty, the percentage receiving public assistance, and the neighborhood deprivation index. Figure C.1 depicts the relation between the neighborhood deprivation and drug-related arrest rates using a scatter plot.

Table C.3 presents both unadjusted and adjusted associations measuring the influence of SEP accessibility and drug-related police activity on high-risk injection behavior in the past three months. Neither log of the distance to the nearest SEP nor drug-related arrest rates were associated with indicators of high-risk injection behavior.

In summary, neighborhood socioeconomic disadvantage was associated with both increased SEP accessibility and increased drug-related police activity. The direction of these associations is consistent with what we might hypothesize. However, neither SEP accessibility nor drug-related police

activity were associated with high-risk injection behavior, suggesting that these variables did not mediate relations between neighborhood socioeconomic disadvantage and high-risk injection behavior in our sample. As a result, we focus our main analyses on the role of SEP accessibility and drug-related police activity as effect modifiers.

APPENDIX C TABLES AND FIGURES

Table C.1 Unadjusted associations between indicators of neighborhood socioeconomic disadvantage and the log of distance to the nearest syringe exchange program among PHARM-Link study participants (N=484)

Indicator of neighborhood socioeconomic disadvantage	Proportional change in distance to the nearest syringe exchange program (95% CI)
% poverty	-33% (-49%, -13%)[a]
% public assistance	-64% (-82%, -26%)[a]
% low education	-14% (-32%, 11%)
% unemployed	-49% (-75%, 3%)
% residential instability	14% (-26%, 75%)
Neighborhood deprivation index	-38% (-53%, 17%)[a]

[a] $p < 0.05$

Note: Values shown are proportional changes in distance to the nearest syringe exchange program and 95% confidence intervals calculated from linear regression models in which generalized estimating equations were used to account for autocorrelation within community district areas. Proportional changes reflect a 10% increase (e.g. 10% to 20%) for all indicators of neighborhood socioeconomic disadvantage, with the exception of neighborhood deprivation index. For neighborhood deprivation index, the proportional change in outcome was estimated for a 4-unit increase.

Table C.2 Pearson correlations between indicators of neighborhood socioeconomic disadvantage and drug-related arrests per 1000 adults in New York City community districts in 2010 (N=68)

	Drug-related arrests per 1000 adults	
	Correlation coefficient	*p-value*
% poverty	0.76	<.0001
% public assistance	0.82	<.0001
% low education	0.57	<.0001
% unemployed	0.39	0.001
% residential instability	0.16	0.195
Neighborhood deprivation index	0.90	<.0001

Note: Community districts with adult populations < 100 were not included in this analysis (N=3).

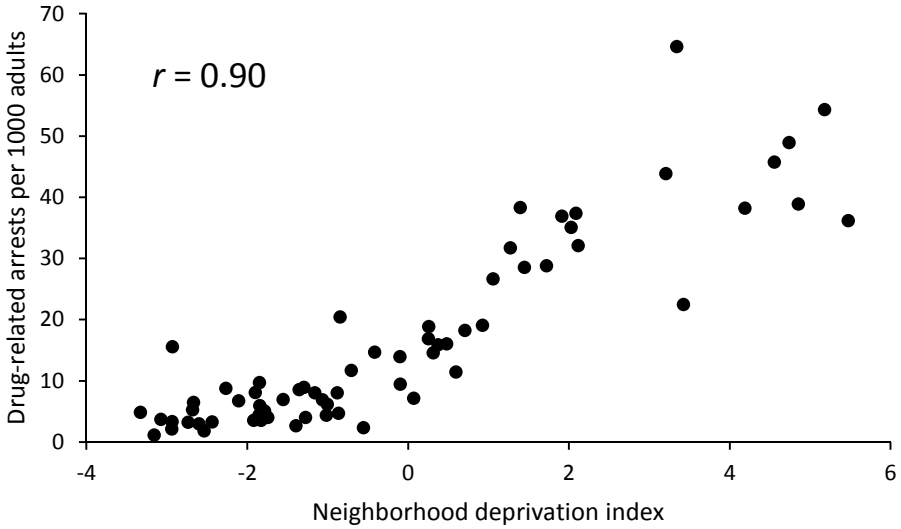

Figure C.1 Scatter plot of neighborhood deprivation index and drug-related arrests per 1000 adults in New York City community districts in 2010 (N=68). Community districts with adult populations <100 are not included in this plot (N=3). *r* = Pearson correlation coefficient.

Table C.3 Unadjusted and adjusted associations of the log of distance to the nearest syringe exchange program and drug-related arrests per 1000 adults with high-risk injection behavior among PHARM-Link study participants (N=484)

	Receptive syringe sharing		**Use of unsafe syringe source**		**Unsterile syringe use**	
	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Log of distance to the nearest SEP	1.02 (0.86, 1.20)	0.95 (0.80, 1.14)	1.00 (0.87, 1.16)	1.04 (0.88, 1.22)	0.99 (0.90, 1.09)	0.96 (0.87, 1.06)
Drug-related arrests per 1000 adults	0.97 (0.88, 1.08)	1.12 (0.97, 1.29)	1.00 (0.92, 1.09)	1.04 (0.92, 1.19)	1.00 (0.94, 1.05)	1.06 (0.98, 1.15)

Note: Values shown are risk ratios and 95% confidence intervals for 1-unit increases in log of distance to the nearest SEP and 10-unit increases in drug-related arrests per 1000 adults. Adjusted models were controlled for neighborhood deprivation index and the following individual-level confounders: age, gender, race, education, income, homelessness, sexual orientation, and injection frequency.