



Original article

Do metropolitan HIV epidemic histories and programs for people who inject drugs and men who have sex with men predict AIDS incidence and mortality among heterosexuals?

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ABSTRACT

Purpose: We focus on a little-researched issue—how human immunodeficiency virus (HIV) epidemics and programs in key populations in metropolitan areas affect epidemics in other key populations. We consider (1) How are earlier epidemics among people who inject drugs (PWID) and men who have sex with men (MSM) related to later AIDS incidence and mortality among heterosexuals?; (2) Were prevention programs targeting PWID or MSM associated with lower AIDS incidence and mortality among heterosexuals?; and (3) Was the size of the potential bridge population of noninjecting drug users (NIDUs) in a metropolitan area associated with later AIDS incidence and mortality among heterosexuals? **Methods:** Using data for 96 large U.S. metropolitan areas, Poisson regression assessed associations of population prevalences of HIV-infected PWID and MSM (1992); NIDU population prevalence (1992–1994); drug use treatment coverage for PWID (1993); HIV counseling and testing coverage for MSM and for PWID (1992); and syringe exchange presence (2000) with CDC data on AIDS incidence and mortality among heterosexuals in 2006–2008, with appropriate socioeconomic controls.

Results: Population density of HIV+ PWID and of NIDUs were positively related, and prevention programs for PWID negatively related to later AIDS incidence among heterosexuals and later mortality among heterosexuals living with AIDS. HIV+ MSM population density and prevention programs for MSM were not associated with these outcomes.

Conclusions: Efforts to reduce HIV transmission among PWID and NIDUs may reduce AIDS and AIDS-related mortality among heterosexuals. More research is needed at metropolitan area, network, and individual levels into HIV bridging across key populations and how interventions in one key population affect HIV epidemics in other key populations.

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Introduction

Community network studies, research on group sex events [1,2], and other data show that sexual relationships among people who inject drugs (PWID), among men who have sex with men (MSM), among noninjecting drug users (NIDUs), and among other heterosexuals are common [3–11]. NIDUs may be a group through which

human immunodeficiency virus (HIV) is transmitted from PWID and MSM to heterosexuals [12–19].

Insofar as we know, little research has been conducted on how epidemics and programs in one key population affect those in other key populations, although one phylogenetic study [20], one historical study, and some attempts to use mathematical modeling [21,22] have explored this issue. Previously, we investigated the association between HIV prevalence among MSM and that among PWID in 96 large metropolitan statistical areas in 1992 [23,24]. Here, in the absence of adequate metropolitan-level data on HIV incidence or prevalence among heterosexuals after 1992, we focus on an important subset of research questions on this topic: (1)

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Table 1
Descriptive statistics on independent variables for 96 large U.S. metropolitan statistical areas

Variable	N	Median (range)	Mean (SD)	1st Quartile	3rd Quartile	Data source
Epidemiologic factors						
HIV-positive high-risk heterosexuals per 10,000 adult population 1992 ^a	96	1.35 (0.20–19.14)	2.63 (3.48)	0.83	2.60	Holmberg [38]
HIV-positive PWID per 10,000 adult population 1992 ^a	96	4.06 (0.74–80.63)	9.20 (13.88)	2.28	9.97	Holmberg [38]
HIV-positive MSM per 10,000 adult population 1992 ^a	96	11.25 (2.64–134.07)	15.63 (15.29)	7.97	17.62	Holmberg [38]
NIDUs per 10,000 adult population 1992–1994	92	456.88 (90.30–3371.61)	598.52 (484.34)	319.50	651.48	TEDS [86] and Tempalski et al. [29]
Economic conditions						
Household Gini coefficient 1989	95	0.43 (0.38–0.51)	0.43 (0.02)	0.41	0.44	Harper [87]
Percent living below poverty level 1989	96	11.15 (4.23–52.87)	11.92 (5.61)	9.47	13.15	US Census [88,89]
Racial/ethnic residential segregation						
Black/White Dissimilarity Index 1990 ^b	90	64.31 (37.52–89.95)	64.49 (11.86)	56.26	73.21	Mumford Center [90]
Social cohesion						
Religious membership per 10,000 adult population 1990	95	1314.22 (294.65–4945.15)	1669.51 (1036.00)	859.28	2148.30	ARDA [91]
Congregations per 10,000 adult population 1990	95	6.16 (3.19–15.91)	7.01 (2.88)	5.08	8.07	ARDA [91]
Interventions						
SEP 2000	96	0.00 (0–1)	0.44 (0.50)	-	-	Beth Israel Medical Center [92]
Hard drug arrests per 10,000 adult population 1993 ^c	94	11.42 (0.53–71.87)	15.06 (14.18)	4.47	20.41	FBI [93]
Drug use treatment coverage for PWID (% among total PWID pop in 1993)	90	5.60 (0.80–16.40)	6.76 (3.71)	4.20	9.40	Tempalski et al. [35]
HIV Counseling and Testing coverage for PWID (% among PWID at risk in 1992)	79	7.70 (0.14–31.51)	9.16 (6.42)	4.78	12.52	CTS [94] and Holmberg [38]
HIV Counseling and Testing coverage for MSM (% among MSM at risk in 1992)	81	7.09 (0.03–31.38)	7.78 (5.00)	5.00	8.74	CTS [94] and Holmberg [38]

SD = standard deviation.

Reminder: Some variables have substantial measurement error.

^a Holmberg [38] has already reported on these variables.

^b Values on the Index of Dissimilarity are independent of the number of Black and White residents in each MSA.

^c These arrests are an intervention to remove drug users from the street, deter drug use, and perhaps provide medical and social services to those arrested. See reference Friedman et al. [26,27,34] for data on their relationship to key parameters for people who inject drugs.

How are earlier metropolitan HIV epidemics among PWID and MSM related to later AIDS incidence and mortality among heterosexuals?; (2) Were prevention programs that targeted PWID or MSM associated with lower AIDS incidence and mortality among heterosexuals?; and (3) Was the size of the potential bridge population of NIDUs in a metropolitan area associated with later AIDS incidence and mortality among heterosexuals [25–29]? We use the term “heterosexuals” here to mean heterosexuals who do not inject drugs, although we note that an undetermined proportion of those so classified may have injected drugs but not reported it.

Methods

We studied these questions using longitudinal data from 1992 to 2008 on a cohort of metropolitan statistical areas (MSAs). The U.S. Census Bureau defines MSAs as contiguous counties containing a central city of 50,000 people or more that form a socioeconomic unity [30]; we used MSA boundaries as they were defined in 1992. Our studies of HIV epidemics among PWID at the MSA level [23–25,31–37] have shown that each MSA has its own epidemic history, HIV prevalence rate, history of prevention programming, and socioeconomic contexts.

This article is part of a study on HIV epidemics among PWID in the 96 MSAs that had populations of 500,000 or more in 1992. The study design is a longitudinal study at the MSA level of analysis. As such, it can be considered an “ecological cohort” study of MSAs as social and epidemiologic units. Given the complex pathways likely to connect HIV epidemics among different key populations, this design has important strengths and limitations that are described

in the Discussion section. Due to missing data on dependent and key independent variables, the number of MSAs in the models presented in Tables 3 and 4 is less than 96 and varies depending on which variables are included in a given model.

Data

Data on both outcomes (AIDS incidence; and mortality among heterosexuals aged 15–64 years living with AIDS) for 2006–2008 in each MSA were obtained by special request from the U.S. Centers for Disease Control and Prevention. We divided these by the number of adults (aged 15–64 years) living in each MSA to calculate population-based rates.

Other data sources are described in Table 1. Estimates of numbers of HIV-positive MSM and PWID and on population numbers of MSM and PWID in 1992 were taken from Holmberg [38]. Although reported in Table 1, data on HIV-positive high-risk heterosexuals per 10,000 adult population were not included in the statistical analyses because they were highly correlated with HIV prevalence estimates for PWID ($r = 0.88$) and because they were for the hard-to-define “high-risk” heterosexual population rather than for the entire heterosexual population, which is the population this article is studying. These were calculated using methods such as back-calculation that have become more complicated after the development and spread of highly active antiretroviral therapy [39]. Although these techniques have been used to create national-level incidence estimates [39], they would be very time-consuming and less accurate at the metropolitan area level. Although estimates for numbers of PWID for these metropolitan areas are available (Table 1), estimates of numbers of MSM are available only for 1992

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