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HIV and risk environment for injecting drug users: the past, present, and future

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Abstract

We systematically reviewed reports about determinants of HIV infection in injecting drug users from 2000 to 2009, classifying findings by type of environmental influence. We then modelled changes in risk environments in regions with severe HIV epidemics associated with injecting drug use. Of 94 studies identified, 25 intentionally examined risk environments. Modelling of HIV epidemics showed substantial heterogeneity in the number of HIV infections that are attributed to injecting drug use and unprotected sex. We estimate that, during 2010–15, HIV prevalence could

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Contributors

SAS devised the topic for systematic review and modelling, was lead author of the report, and oversaw the review process. TBH devised and carried out the modelling scenarios and wrote corresponding methods, results, and interpretation sections. CAH, TR, and NB extracted and categorised data for systematic review, assisted with collection of secondary data for the modelling scenarios, and helped to write the report and interpret results. RB and RA provided primary data for modelling scenarios, and assisted with interpretation of results and report revision.

Steering committee

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Conflicts of interest

We declare that we have no conflicts of interest.

be reduced by 41% in Odessa (Ukraine), 43% in Karachi (Pakistan), and 30% in Nairobi (Kenya) through a 60% reduction of the unmet need of programmes for opioid substitution, needle exchange, and antiretroviral therapy. Mitigation of patient transition to injecting drugs from non-injecting forms could avert a 98% increase in HIV infections in Karachi; whereas elimination of laws prohibiting opioid substitution with concomitant scale-up could prevent 14% of HIV infections in Nairobi. Optimisation of effectiveness and coverage of interventions is crucial for regions with rapidly growing epidemics. Delineation of environmental risk factors provides a crucial insight into HIV prevention. Evidence-informed, rights-based, combination interventions protecting IDUs' access to HIV prevention and treatment could substantially curtail HIV epidemics.

Introduction

The estimated number of injecting drug users (IDUs) worldwide was 15.9 million (range 11.0–21.2 million) in 2007,[1] of whom around 3 million were infected with HIV. HIV infection was reported in 120 (81%) of the 148 countries in which use of injecting drugs was documented. HIV prevalence in IDUs was 20–40% in five countries and more than 40% in nine.[1] Extreme heterogeneity in HIV epidemics between, and sometimes within, countries, and the tendency for rapid HIV transmission between IDUs have been hallmarks of HIV epidemics associated with IDUs since the pandemic began.

Since sharing of syringes by IDUs was identified as a risk factor for HIV infection nearly 25 years ago, investigators have concentrated on circumstances in which sharing occurs (ie, who injects with syringes previously used by whom, the reasons for sharing, and locations where sharing takes place). Efforts have been made to differentiate risks for acquisition of HIV from injection with used syringes (ie, risk to self) versus loaning, renting, or selling of syringes (ie, risk to others); use of potentially contaminated syringes to measure or mix drug preparations (eg, frontloading or backloading); and the joint use of injection paraphernalia (eg, cookers, cotton, water, or ampoules).[2] The role of personal and social networks as key influences of HIV risk behaviours in IDUs has been reported, consisting of studies of HIV serostatus of network members and subgroups of IDUs that can form transmission bridges (eg, male IDUs who have unprotected sex with other males, or IDUs who are sex workers).[3] Although we mainly discuss HIV transmission risks within populations of IDUs, transmission from IDUs to people who do not inject drugs is a major concern in some countries with established HIV epidemics related to injecting drug use.[4–6]

Increased appreciation of the social determinants of health has given rise to interest in the mapping of social, structural, and environmental factors that shape risk of HIV acquisition.[7] Increasingly, epidemiological and social science research[7–12] promulgates the idea that individual HIV risk practices are shaped by social context and environment, and hence that HIV risk is socially produced.[7,13] The conceptual framework of risk environment guides research measurement and interpretation on the social basis of drug-related harm, and encourages a focus on interactions between risk factors exogenous to the individual,[7] rather than endogenous factors (eg, age, sex, race, or genetic composition), risk practices (eg, joint

use of needles and syringes, or unprotected sex), or pathogenic characteristics (eg, HIV subtype, or drug resistance).

Figure 1 shows how physical, social, economic, and political environments are posited to interact with microenvironmental and macroenvironmental factors to confer risk or protection for HIV infection in injecting drug users,[11,13] and panel 1 lists these environmental risk factors. Macroenvironmental influences include drug-trafficking patterns (physical), gender inequities (social), criminal justice expenditures (economic), or policies and laws for harm-reduction programmes (political).[13] Microenvironmental influences include injection locations (physical), relationship dynamics (social), survival sex trade (economic), and coverage of harm reduction programmes (political). All these factors are constantly interacting, and often overlap with synergistic effects on HIV incidence.

So far, the empirical basis for models of HIV risk environments has come from qualitative and social science research.[11] Despite increased methodological interest in the development of social epidemiological and modelling approaches to the study of HIV determinants,[8,9] little work has been done to assess the extent to which published epidemiology studies of HIV risk and injecting drug use map to the conceptual framework of risk environment.

Systematic review and modelling

We systematically reviewed epidemiological research about risk factors for HIV acquisition in IDUs during the past 10 years. We assessed the extent to which existing evidence and epidemiological studies are congruent with a risk environment approach for delineation of risk factors of HIV acquisition, to improve our understanding of social determinants of HIV and its prevention.

We also provide mathematical modelling projections for two cities with serious HIV epidemics in IDUs (Odessa, Ukraine and Karachi, Pakistan) and one city with an emerging drug-related epidemic (Nairobi, Kenya). These models allow us to assess the heterogeneity, influence of the environment, and potential effect of interventions for different environmental factors, in isolation and in combination in epidemics.

Six independent reviewers extracted data from the papers identified in the search strategy and entered them into a coding form that registered information about type of endogenous and exogenous risk factors, correlates of HIV transmission, magnitudes of association, study design, and location. We recorded study design features (sample size, location, years of data collection, and if prospective, cross-sectional, or ecological design), and whether data were from low and middle-income countries or high-income countries, what type of environmental influence (eg, macroenvironmental or microenvironmental, or physical, social, economic, or political) the study was designed to measure, and whether potential pathways were explored through interactions or stratified analyses. A randomly selected 10% were verified by a second reviewer. Coded data were mapped to the various types of environmental influence according to the risk environment framework described by Rhodes and Simic[13] (panel 1). Data for the required modelling variables (tables 1–3, panel 2, and webappendix pp 13–33) were abstracted by native speakers; a randomly selected 10% of documents were independently selected by a second reviewer who verified accuracy.

We modelled potential HIV epidemic trajectories in Odessa, Ukraine (table 1, panel 2), Karachi, Pakistan (table 2), and Nairobi, Kenya (table 3). For Odessa and Karachi, we used a deterministic compartmental modelling approach (for details of the model see webappendix pp 1–12). As with previous studies,[112–114] our model was of HIV transmission in an IDU population through shared use of injecting equipment and sexual contact. Transmission of HIV to the IDU population from people who do not inject drugs was assumed to be small, and was not included in the model. The modelled population consisted of IDUs who might or might not have reused non-sterile injecting equipment or been sexually active, and who were men, women, bisexual men (men who have sex with men and women), or homosexual men (men who have sex only with men [MSM]) (figure 2). Reductions in shared syringe use can arise either through increased access to sterile injecting equipment (eg, needle and syringe programmes) or through opioid substitution therapy. Our model did not assume any direct interaction between the effects of needle exchange and opioid substitution. If antiretroviral therapy was available, individuals started when their CD4-cell count reached 350 cells per μL of peripheral blood.[115]

Models were analysed in a Bayesian framework, in which previous information was assembled as distributions around every model variable. Subsequent distribution of fitting sets of model variables was constructed to generate estimates for the course of the epidemic with and without intervention scale-up.

For Nairobi, because of the low availability of HIV prevalence estimates and IDU behavioural data, a different model was developed on the basis of an extension of UNAIDS's modes of transmission modelling exercise. This method captured patterns of HIV transmission within and between different population subgroups in Nairobi, consisting of IDUs (subdivided into men and women, men that buy sex, MSM, and female sex workers), sex workers, and those forming casual sexual partnerships.[116,117] Transmission to IDUs from sex partners who were not IDUs was captured in this model.

Determinant outcomes

We identified 2722 studies with the search strategy, retained 146 after reviewing titles, keywords, and abstracts; and reduced this number to 94 after review of the full manuscripts. 24 (26%) of these reports were designed to study some aspect of the HIV risk environment, and 81 (86%) identified at least one microenvironmental or macroenvironmental determinant (panel 1 and webappendix pp 35). Variables were classified as exogenous or endogenous and mapped to the risk environment framework. 37 (39%) reports were prospective or panel studies. Only 35 (37%) were done in low-income or middle-income countries, and 27 (29%) were done in countries where average HIV prevalence in IDUs was 20% or more.

The number of microenvironmental HIV determinants reported substantially exceeded macroenvironmental ones. Most studies of both macroenvironmental and microenvironmental determinants identified social or physical HIV determinants. Microsocial determinants were most frequently reported, including relationship and network dynamics, sexuality and sexual orientation, amount of education, and policing practices. The most frequently recorded microphysical variables included the locations where drugs were injected, homelessness, incarceration, and spatial inequities (eg, differential risk of HIV

infection by city or neighbourhood). For macrophysical determinants, several studies reported population mobility as a risk factor for HIV infection,[40,41,53,84] whereas none measured changes in distribution or drug-trafficking routes. Almost all studies reported macrosocial inequities related to gender or race and ethnicity, as opposed to measurements of social processes such as stigmatisation, or geopolitical forces such as exposure to war or conflict (panel 1).

Although 16 studies reported microeconomic influences as determinants of HIV infection, they exclusively reported associations with survival sex (ie, sex for basic necessities) and the sex trade with measures of income generation or employment, as opposed to costs associated with interventions for prevention (eg, needles, syringes, or condoms) or health care. For micropolitical determinants, nine studies reported coverage of drug treatment, sterile syringes, or HIV testing and counselling as independently associated with HIV infection, whereas no programme-wide policies related to syringe access or housing. Far fewer studies reported macroenvironmental influences related to economics, such as criminal justice expenditures,[75] or policies, such as those governing syringe access[89] or possession of drugs or drug paraphernalia.[85,93]

Modelling of HIV epidemics

Case 1: Odessa, Ukraine—Ukraine is the most HIV-affected country in Europe and Central Asia, with around 440 000 people aged 15–49 years infected with the virus (HIV frequency of 1.63%).[118] In some cities, the frequency of HIV infection in IDUs rose from nearly zero in 1994 to more than 50% in 2 years, and as many as 820 400 people might be infected by 2014.[119,120]

Odessa is among the cities bearing the brunt of the HIV epidemic in Ukraine, with the first cases registered in 1987, and outbreaks documented in 1995.[121] As in the rest of country, the epidemic was chiefly attributed to heterosexual transmission. However, by 1997, IDUs accounted for nearly 85% of all cases of HIV infection. Unprotected sex and injecting practices, including drawing of drug solutions from common containers, shared syringe use, and unprotected sex with concurrent casual or sex-trade partners, continued to fuel the epidemic.[95,97] Young IDUs are more likely to engage in risky behaviours; 38% of all people infected with HIV in Odessa are 21–30 years old.[122] Growing use of stimulants, especially in young people, leads to increased engagement in high-risk sexual and injecting behaviours; and drug-treatment programmes fail to reach stimulant users because they mainly target users of opiates.[97]

High rates of corruption, pervasive poverty, and marginalisation of drug users are epidemic macroenvironmental forces, as explained through the voices of people who inject drugs (panel 2). Since 2004, government spending directed at increased access to antiretroviral therapy, harm reduction, and buprenorphine maintenance has substantially increased,[118] but remains suboptimal[109] (table 1). Although 12–13% of the prison population injects drugs, there are no needle and syringe programmes or opioid substitution treatments available to prisoners.

Figure 3 shows the rapid spread of HIV in Odessa in the late 1990s, which has since stabilised at 50% prevalence. Few measures of the early rate of HIV spread and the small sample sizes of available prevalence estimates implied that a wide range of alternative epidemic trajectories were supported by the data, leaving substantial uncertainty in model projections. If we assume there will be no further change in risk in IDUs in Odessa, we predict there will be 6200 (95% credible interval 4500–6500) new HIV infections in IDUs between 2010 and 2015 (figure 3). New HIV infections from injecting drug use are mostly (40–80%) attributed to exposure to contaminated injection equipment, but another substantial route of transmission is unprotected sex between IDUs (15–45%).

Suboptimal access to clinically indicated antiretroviral therapy (CD4-cell count ≤350 cells per μL) causes 40–47% of infections. Many HIV infections in IDUs could be averted through timely and widespread interventions that reduce the frequency with which IDUs use non-sterile equipment. A 60% reduction in the unmet need of opioid substitution services could avert 10% (5–18%) of new infections, and a similar reduction in unmet need ofneedle and syringe programmes could avert 5% (2–8%) (figure 3). However, even in these optimistic scenarios, many infections would still arise because of the residual risk from contaminated injection equipment and unprotected sex. Therefore, a scale-up of these programmes should proceed alongside equitable scale-up of antiretroviral therapy and support for behavioural changes and condom promotion in this setting. 41% (32–47%) of infections could be averted if coverage of opioid substitution therapy and needle-exchange programmes were scaled to reduce unmet need by 60%, and if 60% of IDUs were initiated promptly on antiretroviral therapy when indicated.

Elimination of police beatings in Odessa, Ukraine—Removal of an environmental risk factor can have a substantial effect on incidence of HIV infection. Our reviews[41,51,75] and other studies (see papers 48, 49, 60, 62–64, and 66 in webappendix pp 38–39) suggest that policing practices can directly affect the risk of HIV acquisition by affecting where, when, with whom, and the context within which drugs are injected (eg, IDUs rushing injections or injecting in shooting galleries to avoid arrest). Police can also have an indirect effect on HIV risk, via pressuring or displacing IDUs away from needle and syringe programmes or drug-treatment settings.[123] Problematic policing practices include arresting of drug users for carrying of sterile or used syringes, harassments at needle and syringe programmes or drug-treatment clinics, soliciting of bribes to avoid arrest, or in extreme cases, sexual abuse or violence. These actions can increase the chance of IDUs injecting with contaminated equipment. 24% of IDUs in Odessa report ever being beaten by police (table 1 and panel 2),[99] and these people are more likely to report shared syringe use, use of preloaded syringes, and frontloading or backloading of syringes, among other risk behaviours.[124] We suggest that elimination of police beatings would remove the excess in risk behaviour, across the population, that stems from some individuals ever having been beaten. The effect of this assumed change in risk behaviour on HIV incidence in Odessa was estimated with the model (see webappendix p 10).

Our model projects that a substantial number of new HIV infections could be prevented in Odessa by 2015 through elimination of police beatings (figure 4). In two other Ukrainian cities, Makeevka and Kiev, where beatings are less associated with increased risk behaviour

(Booth R, unpublished data), we estimate 2–9% of infections could be averted. The influence of police beatings and other practices on HIV incidence probably varies by location and operates through several direct and indirect causal pathways, making precise quantitative estimates impossible to generate without additional data. Additional studies with quantitative and qualitative methods are needed to elucidate the magnitude and direction of these associations, and intervening variables and the interplay between them. We will then be able to assess the effect of elimination of these human rights violations on HIV incidence in IDU populations.

Case 2: Karachi, Pakistan—Pakistan has had a thriving heroin consumption market for decades, and is neighbour to Afghanistan, the world's largest producer of opium. In the 1980s and 1990s, national surveys[107] suggested that the number of drug users increased yearly by 12%, with most people who used drugs taking heroin by inhalation or smoking. In the past 10 years, however, changes in drug trafficking and distribution prompted transitions from smoking of heroin to injection of heroin, liquid opiates, and other pharmaceuticals, these being readily available over-the-counter at chemist shops. By 2000, there were an estimated 500 000 people who used drugs nationwide,[108] of whom 15–30% were IDUs.[107] Although non-therapeutic drug use, prostitution, adultery, and homosexuality are illegal in Pakistan, all are widespread.[125]

HIV prevalence in Pakistan's population of 91 million aged 15–49 years is low at 0.1% (~96 000 people). However, HIV outbreaks in IDUs occurred in Larkana in mid-2003,[107] and in Sargodha, where HIV prevalence in IDUs rose from 9% in 2005–06, to 51% in 2007.[50] HIV prevalence was 23% in Karachi, Pakistan's most populous city in 2003,[101] where there were 9000 IDUs in 2006,[107] and was 19.6% in nearby Sukkur and 18.3% in Hyderabad. As in other cities, most IDUs in Karachi are male; 2–3%[107] of female sex workers inject drugs, and 20–25% of these workers report having sex with IDUs.[107] About half of male IDUs in Karachi are married;[101] 47% reported having sex with female sex workers,[105] and 9–14%[101,105] reported having sex with a male sex worker or hijra (transsexual) in the past month—two-thirds never use condoms.[105]

Challenges to prevention include the tendency for IDUs to use professional injectors (hit doctors), inject together in groups with common syringes or ampoules (79.5% of all injection drug users),[105] and mix their blood with drug preparations before passing it on in an effort to potentiate the high. Furthermore, in the previous year, 16% of IDUs in Karachi reported visiting other cities in Pakistan,[101] and 28% reported selling their blood.[106]

Needle and syringe programmes are present in Karachi and in many major cities in Pakistan, [107] some of which provide mobile services, but coverage is grossly insufficient.[109] Detoxification and residential rehabilitation are the predominant strategies for drug treatment. Although buprenorphine maintenance therapy has been piloted in a few cities,[109] opioid substitution remains unavailable. In 2009, less than 1% of IDUs with HIV infection were receiving antiretroviral therapy.[109] Although Pakistan's epidemic is concentrated, it could be increasingly difficult to contain if reported rates of highrisk behaviours continue, or if high rates of transition to injection happen as a result of macroenvironmental changes in

drug markets (ie, reduced availability or purity and increased price of heroin), in the absence of effective prevention scale-up.

In Karachi, the HIV epidemic spread in the late 1990s, although the earliest prevalence measurement in 1995 suggested little evidence of HIV penetration in IDUs. However, by 2003, estimated HIV prevalence in this group was 23% (figure 5), which rose to 30.1% in 2006, and decreased to 23.1% in 2008.[101] We estimate that HIV incidence will stabilise, with 2400 (95% credible interval 1300–4400) new HIV infections in IDUs in 2010–15.

Modelling provides most support for rapidly growing epidemics beginning after 2000, because of the high degree of shared use of injection equipment.[105,106] Although a quarter of male IDUs have sex with female sex workers,[101] the low HIV prevalence in female sex workers in Karachi and the relative frequency and probability of transmission through sex and injection behaviours suggest that little transmission is attributable to this route. Furthermore, only about 4.6% of HIV infections are attributed to unprotected sex with other IDUs (figure 5). However, the proportion of HIV infections attributable to inadequate antiretroviral therapy coverage is substantial (19–40% if antiretroviral therapy is started at CD4-cell count ≤350 cells per μL), but is marginally lower than that reported in Odessa because of the higher proportion of cases of incident HIV caused by injection behaviour in Karachi.

Non-injecting drug users might increasingly transition to injecting in the coming years, and, because of the large numbers of these people in Karachi,[50] the spread of the epidemic could accelerate. If 10% of non-injecting drug users started injecting in 2010, the number of new HIV infections could increase by 82% by 2015 (~4000 extra infections) compared with the most conservative scenario that assumes no transitions (figure 5). If 12% of non-injecting drug users started injecting, the increase in new infections in IDUs in Karachi would be close to 98% (4400 extra infections). Because of the virtual absence of opioid substitution in Pakistan, implementation and scale-up of this therapy could have a substantial effect on reduction of shared syringe use by lessening of the frequency of injections or the number of active IDUs. If 60% of IDUs in Karachi were to be given opioid substitution, the number of new HIV infections could decrease by up to 28% in 2010–15. Thus, actions to limit the quantity of drug users who transition to injecting and a substantial scale-up of opioid substitution therapies are two priority interventions for Pakistan.

Case 3: Nairobi, Kenya—Kenya is in eastern Africa, borders the Indian Ocean between Somalia and Tanzania, and has a population of 39 million, 42% of whom are younger than 15 years of age. 1.5–2 million adults and children had HIV in 2007, of whom 1.4–1.8 million were aged 15 years and older.[126] Only a quarter of Kenyans with HIV infection know their serostatus.[117] Urbanisation is happening at an estimated 4% annual rate of change (2005–10 estimate), and the capital city, Nairobi, has an estimated population of 3.04 million. Recreational drugs taken in Kenya include bhangi (herbal cannabis), heroin, khat (a plant with amphetamine-like properties), flunitrazepam, diazepam, glue, and alcohol.[127] Estimates of the number of people who take heroin vary from 12 201,[117] to 18 000,[127] up to 24 500.[116] Overall, less than 10% of heroin users are thought to have injected.[117] However, one study[128] reported that 44.9% of Nairobi heroin users had injected and 52.5% of 101

present injectors were HIV positive, compared with 13.5% of 181 non-injecting heroin users.[128] Hepatitis C prevalence was 61.4% in the presently injecting group compared with 3.8% in those not injecting. In 2005, although only 0.3% of the adult male population were injecting drugs, an estimated 4.8% of new HIV infections happened through this route.[116] Although 73% of Nairobi injectors knew about the risks of HIV transmission in 2005, 28% had used a needle after someone else, and 43% had passed their own needle to another person in the past 6 months.[129] By 2008, injection-drug use accounted for 3.8% of incident HIV infections in Kenya (5.8% in Nairobi).[117]

Kenya's national AIDS strategic plan for 2010–13 referred to development of policies and legislation for the provision of needle and syringe programmes and opioid substitution therapy for the first time. Needle and syringe programmes are not permitted by law in Kenya,[109] but some non-governmental organisations in Nairobi and Mombasa reportedly provide education about harm reduction. There are very few opioid substitution services in private clinics in Kenya, and substitution therapy is not permitted in public clinics because of rigid interpretation of a law regulating opiate pain medications. Treatment that is not reliant on non-opioid substitution for drug dependence is available in government hospitals and is provided by non-governmental organisations.[129] The number of people receiving antiretroviral therapy in Kenya rose from 29 000 in 2004,[126] to 242 881 in 2008,[130] but less than 1% of IDUs who were HIV positive were receiving therapy in 2008.[109]

The HIV epidemic in IDUs in Nairobi will grow substantially; 4000 (95% CI credible interval 2600–5400) new HIV infections are expected from 2010 to 2015, 95% as a direct result of exposure to contaminated injecting equipment and 5% from sexual transmission (figure 6). In the model, the much higher rate of non-sterile equipment use in Nairobi than Odessa or Karachi leads to a lower proportion of risk of HIV infection for injection drug use via unprotected sex there, despite the much higher prevalence of HIV infection in sexual partners. The high rate of non-sterile equipment use could also undermine the effect of needle and syringe and opioid substitution programmes (figure 6). Scale-up of needle and syringe programmes to reach 40% of the population might reduce HIV prevalence by as little as 4%, assuming that such a programme halves the frequency of injections with nonsterile equipment.

However, a combination of interventions at high coverage would have a far greater effect; 80% coverage of both opioid substitution and needle and syringe programmes could avert around 1100 (26%) infections by 2015. Elimination of laws prohibiting opioid substitution and scaling up services to 80% of IDUs could reduce the number of incident HIV infections by 14%. If increased coverage of antiretroviral therapy is added to opioid substitution and needle and syringe programmes, with rapid initiation when CD4-cell counts are lower than 350 cells per μL, about 1800 (45%) infections could be averted. However, the high rate of reported risk behaviour in the population implies that, even with all these interventions at full coverage, there could still be more than 2000 new infections in IDUs during 2010–15. Thus, to further reduce the effect of this epidemic, sustaining of high-coverage, high-effectiveness needle and syringe programmes and opioid substitution interventions will be crucial. With an effectiveness rate of 70% (rather than 50% assumed elsewhere, see webappendix p 11), and with 80% of the population accessing needle and syringe and opioid

substitution programmes, our model suggests that almost 2500 (~67%) new infections could be prevented.

Implications

Comment—Our systematic review of the published work from the past decade, and modelling scenarios of local HIV epidemics in three diverse cities emphasises the important role of the risk environment in vulnerability to HIV infection in people who inject drugs. Although the published work suggested that physical, social, economic, and political environments can be microenvironmental or macroenvironmental, and are independently associated with HIV infection in injectors, only a quarter of studies were designed to assess environmental influences. Even fewer tried to measure macroenvironmental influences, or economic or political determinants. Fewer than a third of studies were done in countries with the greatest burden of HIV infection in IDUs, suggesting that research has not kept pace with the rapid evolution of HIV epidemics in people who inject drugs.

Research of the HIV risk environment—Heuristics of the HIV risk environment (figure 1 and panel 1) provide a loose theoretical framework for empirical efforts to improve the evidence-base on the social relations of HIV transmission.[11,13] Undertaking of epidemiological studies that explicitly delineate social-determinant causal pathways for HIV infection to inform social and structural approaches to HIV prevention is daunting.[131] Although our review shows that epidemiological studies rarely explicitly embrace investigations of social determinants, they nonetheless identify environmental risk factors as important. We contend that future epidemiological studies of HIV in IDUs should make use of the methods and findings of qualitative and social science research in their efforts to systematically delineate how microenvironmental and macroenvironmental influences combine to increase or reduce HIV risk. We advocate for fully integrated mixed-method approaches that triangulate findings from qualitative and quantitative methodologies.

Findings from our review present challenges for future research. Investigations should shift from binary epidemiological models of straightforward cause and effect to multifaceted models that emphasise HIV infection as an outcome of many contributing factors interacting at once.[11] Social determinants are often complex and indirect in their effects with intervening factors (panel 2), and are a substantial challenge to delineation of causal relationships. For example, policing practices can affect the extent to which IDUs engage in protective behaviours in many ways, from reducing their ability to avoid use of contaminated injection equipment or access to needle and syringe programmes, to increasing the likelihood of injection in locations with a high prevalence of HIV (eg, shooting galleries or prison).

Theoretical models of HIV risk environments need to shift from heuristics that list factors (panel 1) to those that model interactions, processes, and pathways (figure 1). Furthermore, an emphasis on protective factors such as resilience, social cohesion, and solidarity is needed for individuals, communities, and populations. Because present epidemiological studies mainly focus on determinants of risk behaviour, rather than HIV infection, there is a need to understand the links between downstream or proximate factors and upstream or more distal

influences on behaviour. Interventions on the basis of observational studies that are too narrow or superficial in scope tend not to address social contexts that shape behaviour, and therefore might be unable to create enabling environments that preserve and promote the protective resilience that can prevent the emergence of HIV epidemics.

A few studies were exceptions to the rule, and can serve as models for future studies. In an ecological study of 96 metropolitan areas in the USA, Friedman and colleagues[75] reported that three measures of legal repressiveness (arrests for possession of cocaine or heroin, police staff per capita, and costs for corrections) were independently associated with population HIV prevalence. Innovative use of administrative data allowed the investigators to change the unit of analysis from the individual to the community, allowing simultaneous study of the effect of macrosocial and macroeconomic influences on HIV prevalence. Wood and colleagues[30] prospectively examined the effects of reduction of plasma HIV-1 viral load in a community on HIV incidence in IDUs. In this study, undetectable rates of HIV-1 viral load in the community were a marker of antiretroviral therapy coverage, which permitted causal inferences to be made about the effect of policies of universal access to antiretroviral therapy on risk of HIV acquisition for the individual.

Review limitations—Other eligible reports could have been selected with different keywords, and we might not have included all studies that explored the effect of risk environments on high-risk behaviours. Because we explicitly focused on the epidemiology of HIV risk environments, our review did not include empirical or theoretical social science studies on the social, economic, and structural determinants of HIV and health inequality. A well-established body of published work from social science exists on the political economy of HIV and drug-related health.[11]

The environmental risk determinants summarised in panel 1 are inevitably restricted in scope to those factors that epidemiological research has previously operationalised and found significant. Epidemiological research and subsequent reviews should build on social science to hypothesise and test other social, political, and economic influences that indirectly affect the risk of HIV acquisition through many, presently not delineated, pathways.

Another limitation is that models of risk environment draw distinctions between microenvironmental and macroenvironmental factors, and forms of risk environment (physical, social, economic, political). Analytically, these definitions are often somewhat overlapping of each other in practice. Police practices can be classified as a microenvironmental effect in some studies, affecting social environment, or a macroenvironmental effect of law enforcement, policy, and other cultural practices.

Modelling of the HIV risk environment—Our modelling scenarios confirmed the importance of structural change on the projected HIV epidemic trajectories in Odessa, Karachi, and Nairobi in the next 5 years. Since coverage of antiretroviral therapy for IDUs in these cities is very low (<1%), the benefits of providing optimal therapy for those with CD4-cell counts lower than 350 cells per μL are compelling, and could avert 40–50% of incident HIV infections in Odessa and Karachi. Implementation of widespread coverage of

antiretroviral therapy to IDUs when clinically indicated to avert immediate HIV-related deaths is a clinical and moral imperative. Our results and other findings[30,132] suggest that antiretroviral therapy can contribute to subsequent reductions in HIV transmission. However, the resources needed to meet such targets, including voluntary HIV testing, efficient linkage and retention in care, CD4 diagnostics, adherence counselling, and resistance monitoring are substantial.

Our results support the well-established role of sterile syringe provision and opioid substitution as cornerstones of HIV prevention in IDUs. However, modelling results suggest that epidemic context alters their potential effect. Our findings from Odessa, Karachi, and Nairobi strongly advocate simultaneous combination of opioid substitution, needle and syringe programmes, and antiretroviral therapy scale up wherever possible, since their effects are synergistic.[132] An important outcome from the Nairobi models is that, in an epidemic in which the force of infection is great (eg, an outbreak), the approximate 50% effectiveness of needle and syringe programmes and opioid substitution (see webappendix p 11) restricts effect as much as does coverage. This finding implies that investment in strategies to optimise intervention effectiveness is needed as coverage increases. Straightforward incremental scale-up will not achieve intended direct and indirect effects if interventions are not tailored, intensified, and otherwise adapted to address local epidemic dynamics.

Data from our review of the published work[19,27,56,57,65,80,82] and our modelling suggest that opioid substitution scale-up should be an intervention priority. Methadone and buprenorphine maintenance have been added to WHO's essential drug list, but have yet to be implemented widely in Kenya, Ukraine, and Pakistan, with potentially disastrous results. Access to therapeutic opioid medications is regulated by specific provisions in UN conventions, and these treaties recognise them as indispensable for medical care.[134] Despite this benefit, treatment for dependency with opiates is not available in Kenya, where the amount of morphine available for palliative care was 0.14 mg per head in 2004—less than 2.5% of the global mean of 5.9 mg per head.[135] One hospice physician stated "Physicians are afraid of morphine...Doctors [in Kenya] are so used to patients dying in pain...they think that this is how you must die. They are suspicious if you don't die this way—[and feel] that you died prematurely."[136] These reports suggest a substantial disconnect between drug-control authorities and the health-care system.[137] Similar to many other lowincome and middle-income countries, national drug control authorities in Kenya have concentrated more on control of illicit use than on facilitation of legitimate medical use.[138] WHO's guidelines for assessment of national opioid control policies adopted in 2000 are anchored in a four-pillar approach aimed at achievement of a balance so drug control does not interfere with medical availability of opioid analgesics for pain relief and opioid substitution.[139] Our model suggests that legislative changes to permit opioid substitution in IDUs in Nairobi could prevent up to 14% of new HIV infections in the next 5 years, assuming 80% coverage.

Apart from the need for enhanced HIV and drug addiction prevention and treatment programmes and policies in Karachi, HIV epidemic projections advocate prevention of the transition from use of non-injection drugs to injection drugs. In Pakistan, where the number of people who smoke or inhale heroin is substantial,[107] macroenvironmental changes in drug

trafficking routes that change the availability, purity, or price of heroin can lead to increased transitions from non-injecting to injecting drug use, as was reported after the terrorist attacks of Sept 11, 2001.[140]

Our modelling scenarios suggest that an 8–12% increase in transition from non-injection drug use to injection drug use, even in the short-term, could lead to around a 65–98% rise in HIV incidence in Karachi in the next 5 years. Such effects are potentiated in the absence of opioid substitution, which could otherwise have a substantial benefit via reduction of the frequency and duration of injections. These findings suggest the need to invest in interventions to prevent transitions to injection and monitoring of perceived changes in local drug markets that might serve as harbingers of changes in injection behaviours.

Modelling limitations—Our modelling analysis allowed a direct quantification of the uncertainty in projections, leveraging substantial information from a wide range of sources. We showed patterns and trends in common with previous work,[112–114] and the explosive HIV epidemics occurring in Vancouver, Canada and Kathmandu, Nepal despite the existence of needle and syringe programmes.[141,142] Estimates of HIV prevalence in IDUs are a good source of epidemiological information, allowing model projections for Odessa and Karachi to be based on direct observational data.

However, our modelling results are limited by the need to make detailed assumptions about forms of behaviour that are highly stigmatised in a hard-to-reach population. Some of the most important model variables, such as IDU population size and the frequency with which IDUs were exposed to potentially contaminated syringes were imprecisely estimated. Reporting of highly stigmatised behaviours can be unreliable. If individuals under-report injecting behaviour, investigators can overestimate the rate of spread of infection or degree of epidemic saturation. If injecting behaviour is under-reported compared with sexual behaviour, the model could overestimate the contribution of sex in epidemics. There tend to be few estimates of HIV prevalence at the start of the epidemic, so the time and speed of initial spread cannot be known precisely. This uncertainty leads to substantial doubt about model projections for future courses of local HIV epidemics, especially because the link between risk behaviours and HIV acquisition is complex, and warrants caution in interpretation of our findings.[114]

Our models used a straightforward representation of opioid substitution and needle and syringe programmes; the effects of opioid substitution on non-HIV mortality and individuals moving in and out of programmes were not captured here, although they are addressed elsewhere in this Series.[133] The deterministic framework used in our models constrained characterisation of the network of contacts between IDUs, and might have influenced our results. If a more complex network topology were represented, for example with distinction of isolated pockets of high-risk behaviour within the IDU population, then the modelled spread of infection might have been more gradual in Karachi, compared with the explosive spread suggested by our model, and therefore the predicted effect of interventions would be reduced. The Nairobi model assumed a homogeneous IDU population that, although not unreasonable on the basis of available reports from outreach groups, could have led to overestimation of the potential for epidemic growth in this population.

Survey data capturing intersecting types of risk in IDU populations and links between IDUs and other at-risk groups, and improved measurement of HIV prevalence, will be most valuable for development of our understanding of epidemics, and modelling and assessment of the effects of interventions.

Conclusion

Many types of environmental influence are important determinants of HIV risk and vulnerability. The modelling scenarios we present support the importance of simultaneously scaling up the coverage of HIV prevention programmes in IDUs (ie, opioid substitution therapy, needle and syringe programmes, or antiretroviral therapy) to produce the best outcomes with their synergistic potential. Adequate coverage of these interventions could not only avert thousands of HIV infections, but also substantially reduce local HIV epidemics through protection of the rights of IDUs to HIV prevention and treatment.

Our findings support the need to shift the focus for change from individuals to their social and political contexts, shifting responsibility for harm to include the social and political–economic institutions that have a role in harm production.[11] Through revelation of the social, political, and economic dimensions of HIV transmission, a risk environment approach allows epidemiology to contribute to strategies for reduction of adverse health outcomes driven by health inequities and social suffering. Creation of enabling environments for HIV prevention is synonymous with the promotion of health and human rights.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key messages

- Understanding of the risks of HIV infection in injecting drug users (IDUs) should go beyond the individual and assess structural and environmental influences that shape risk practices and vulnerability to infection.
- Over the past decade, only a quarter of epidemiological studies explicitly aimed to study risk factors operating in the HIV risk environment in IDUs.
- Over the past decade, fewer than a third of studies that examined risk factors for HIV infection in IDUs were done in countries with high HIV burdens in IDUs.
- Sexual transmission among IDUs and from IDUs to people who do not inject drugs can be a major factor in epidemics; in injectors, risk of HIV infection attributable to unprotected sex was nearly 5% during 2010–15 in Karachi, Pakistan, and Nairobi, Kenya, but was 15–45% in Odessa, Ukraine.
- Reduction of the unmet need of opioid substitution, needle and syringe programmes, and antiretroviral therapy by 60% during 2010–15 could prevent 41% of incident HIV infections in Odessa, 43% in Karachi, and 30% in Nairobi.
- Local HIV epidemics are sensitive to different types and amounts of structural changes: mitigation of the expected transition of non-injecting drug use to injecting drug use by 8–12% in Karachi could prevent 65–98% of incident HIV infections; elimination of laws prohibiting opioid substitution in Nairobi and scaling up of services to 80% coverage could prevent 14% of incident HIV infections in IDUs.
- Extreme heterogeneity in global and local HIV epidemics in IDUs necessitates implementation of a tailored combination of interventions that addresses population determinants of HIV transmission, informed by a comprehensive analysis of local risks operating at many degrees of influence. Structural HIV prevention interventions are a crucial element of a combined prevention approach.
- In regions with rapidly growing epidemics (eg, Nairobi), rapid optimisation of effective and widespread opioid substitution and needle and syringe programmes is crucial. Interventions that protect access to HIV prevention and treatment for IDUs can have substantial effect on local HIV epidemic trajectories.

Search strategy and selection criteria

We searched BIOSIS (ISI-CE BIOSIS previews), PubMed, and Embase for publications written in English, French, Spanish, Ukrainian, or Russian between 2000 and 2009. Our search had three required components: “HIV”, “HIV infections”, “HIV”, “AIDS”, “human immunodeficiency virus”, “acquired immunodeficiency syndrome”, or “acquired immune deficiency syndrome”; “substance abuse, intravenous”, “IDU”, “IDUs”,

"injecting drug", "intravenous drug", "intravenous substance", "injecting substance", or "injecting drug use"; and "risk factor", "correlate", or "determinant". We searched reference lists from retrieved manuscripts. Abstracts were examined to assess eligibility for inclusion, and we excluded studies in which HIV infection was not an outcome, multivariate analyses of risk factors were not done, or data for injecting drug users were not reported separately from those for users of non-injecting drugs. We excluded commentaries, editorials, and reviews. To obtain data for modelling scenarios, the same keywords were used with "Kenya", "Pakistan", and "Ukraine". We also hand-searched published work from the UNAIDS data archive, peer-reviewed abstracts from conference proceedings, and national AIDS programme data.

Risk factors for HIV-1 infection in injecting drug users

Microenvironmental

Physical

- Drug injecting locations[15–25]
- Homelessness[25–31]
- Prisons and incarceration[21,22,27,29,32–39]
- Exposure to violence or trauma[40]
- Spatial inequalities[5,16,29,41–52]
- Location of recruitment[53]

Social

- Social and peer-group norms*
- Relationship and network dynamics[5,15,29,31,36,37,41,42,46,47,50,51,54–68]
- Sexuality and sexual orientation[15,24,53,59,62,64,68,69,70–74]
- Local policing practices and crackdowns[41,51–75]
- Access to community health and welfare services and delivery[69]
- Education[15,19,24,29,76]
- Easy access to drugs[65]
- Peer outreach[77]

Economic

- Cost of living and of health treatments*
- Cost of syringes*
- Cost of condoms*
- Scarcity of income generation and employment[19,34,39,52,55,56,62,78,79]
- Survival sex trade or work[17,56,59,62,64,68,71,80]

Political

- Coverage of sterile needles and syringes[81,82]
- Coverage of drug treatment[19,27,56,57,65,80,82,83]
- Coverage of HIV testing and counselling[72]
- Coverage of highly active antiretroviral therapy[30]
- Programme policies governing distribution of injecting equipment*
- Access to low-threshold and social housing*

Macroenvironmental

Physical

- Drug trafficking and distribution routes*
- Trade routes and population mobility[84]
- Geographical population shifts, neighbourhood and population mixing[53,40]
- Deportation[41]
- Distance from HIV epicentre[85]

Social

- Gender inequalities and gendered risk[32,46,51,69,76,86,87]
- Stigmatisation and marginalisation of drug users*
- Weak civil society and community advocacy*
- Police per capita*[75]
- Exposure to war conflict; or disasters*
- Ethnic or racial inequities[17,27,28,30,45–47,62,65–67,74,88–92]

Economic

- Scarcity of health service revenue or spending*
- Correction expenditures*[75]
- Growth of informal economies*
- Uncertain economic transition*

Political

- Policy and laws governing syringe access and exchange, and enforcement status[89]
- Policy and laws governing drug treatment*
- Policy and laws governing free highly active antiretroviral therapy coverage*
- Public health policy governing sex work and enforcement status*

- Laws governing possession of drugs and drug paraphernalia, and enforcement status[85,93]
- Immigration policies and laws*
- Laws governing protection of human and health rights*

Data from the risk environment framework (2000–09).[13] *Environmental factors and domains identified in social science research and or descriptions of models of HIV risk environments that do not appear in the published work we reviewed.[3,7–9,11]

Voices from Odessa, Ukraine: personal accounts of the risk environment

Police

"There are plenty of problems with police. If they stop you with clean syringes, you get hassled; they will plant drugs in the syringes unless you pay them. They plant drugs in your pocket if they need information. There are many occasions when drug users are beaten by police just because they did not want to take the blame for someone, so they are forced to do it. Some people even get arrested only because they were buying syringes in a pharmacy. They [the police] have no bounds."

Incarceration

"Many of us who have been released from prison have a big problem with documents (passports). While in prison, the documents were lost or expired and one needs money to be able to restore them. And we do not have money. Even if you have a place to live, you need to get registered (to access services), but without documents and money, it's not possible. To get a job is totally unreal. Nobody wants to give a job to former prisoners or drug users. They send us away using all possible ways. Maybe some of us wanted to live clean, but out of desperation, we start selling and using drugs and end up in prison again. It's a vicious circle."

Medical care

"People are scared of drug users, even more so when we are HIV-positive. If you are admitted to hospital and a doctor finds out that you are a hopeless drug user (and he finds out about it very fast), he treats you with disgust. Their entire approach to you amounts to: 'You are a drug user, you will not live long anyway, so what difference does it make what you die from?' Not all of us are HIV-positive, but some doctors 'diagnose' us with HIV anyway. And to receive HIV medicines, you need to be registered (ie, have a registered address)."

Drug treatment

"And the main thing...there is practically no place where one could get free drug treatment. That's a daydream. You need to go there with your own medicine and also give a bribe to the doctor. One has to pay for everything, for a psychologist's help or rehabilitation. And, in the end, we do not have any place where we find understanding and help."

"We do not have enough organisations offering needle exchange, even though these programmes can help us from getting HIV. We really need more of them."

> "After I was arrested, I was experiencing drug withdrawal but I was not given any medical help. I made multiple emergency requests, but the police told me that my death will not distress anyone as they were impudently laughing in my face. We really hope that you will not remain indifferent to our problems."

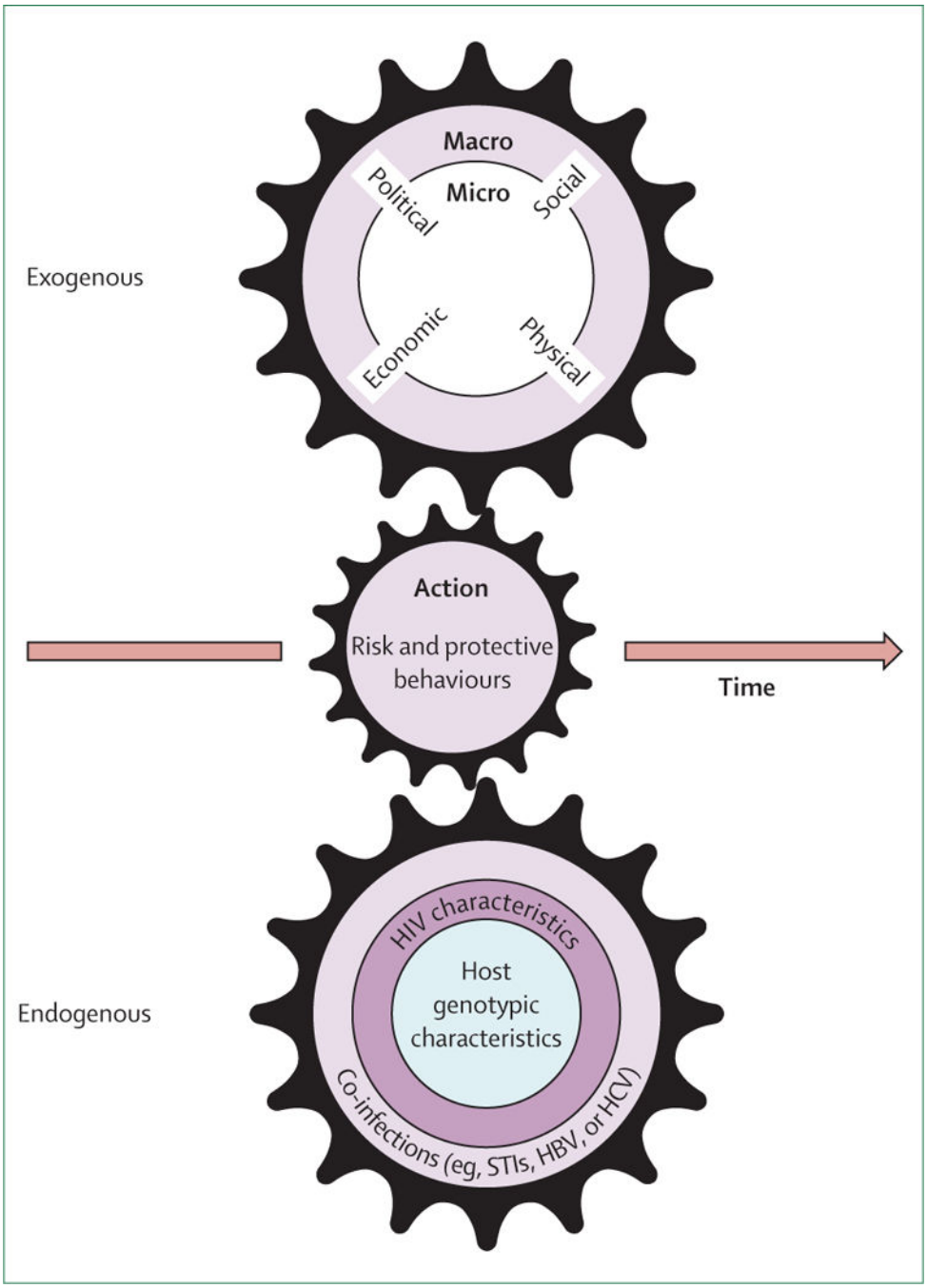

Figure 1: HIV risk factors in injecting drug users

The HIV risk environment is a product of action produced by the continuing, interlocking, and synergistic effects of exogenous and endogenous factors over time. Developed from Glass and McAtee.[14] STI=sexually transmitted infection. HBV=hepatitis B virus. HCV=hepatitis C virus.

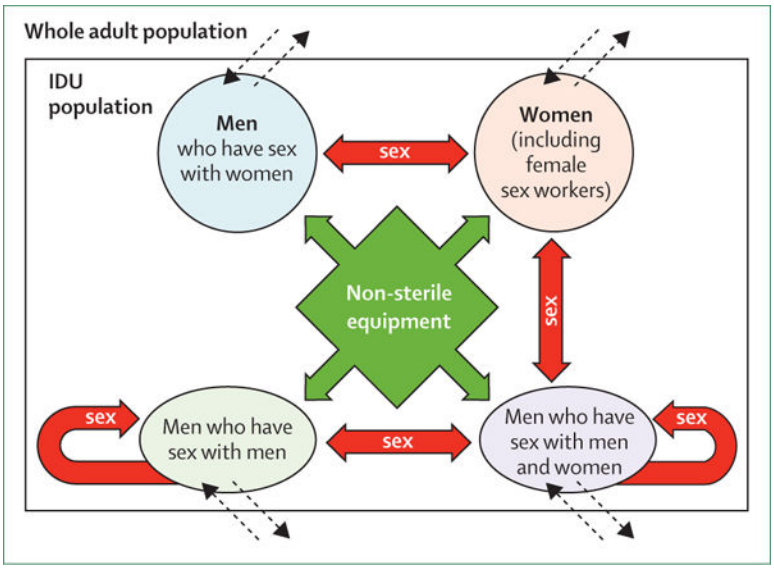

Figure 2: Routes of HIV transmission among populations of IDUs

Population subgroups and risk of HIV infection from shared use of injection equipment (green arrows) and sex (red arrows) are shown. Dashed arrows show entry and exit to the injecting drug user population (ie, start or stop of drug injections). IDU=injecting drug users.

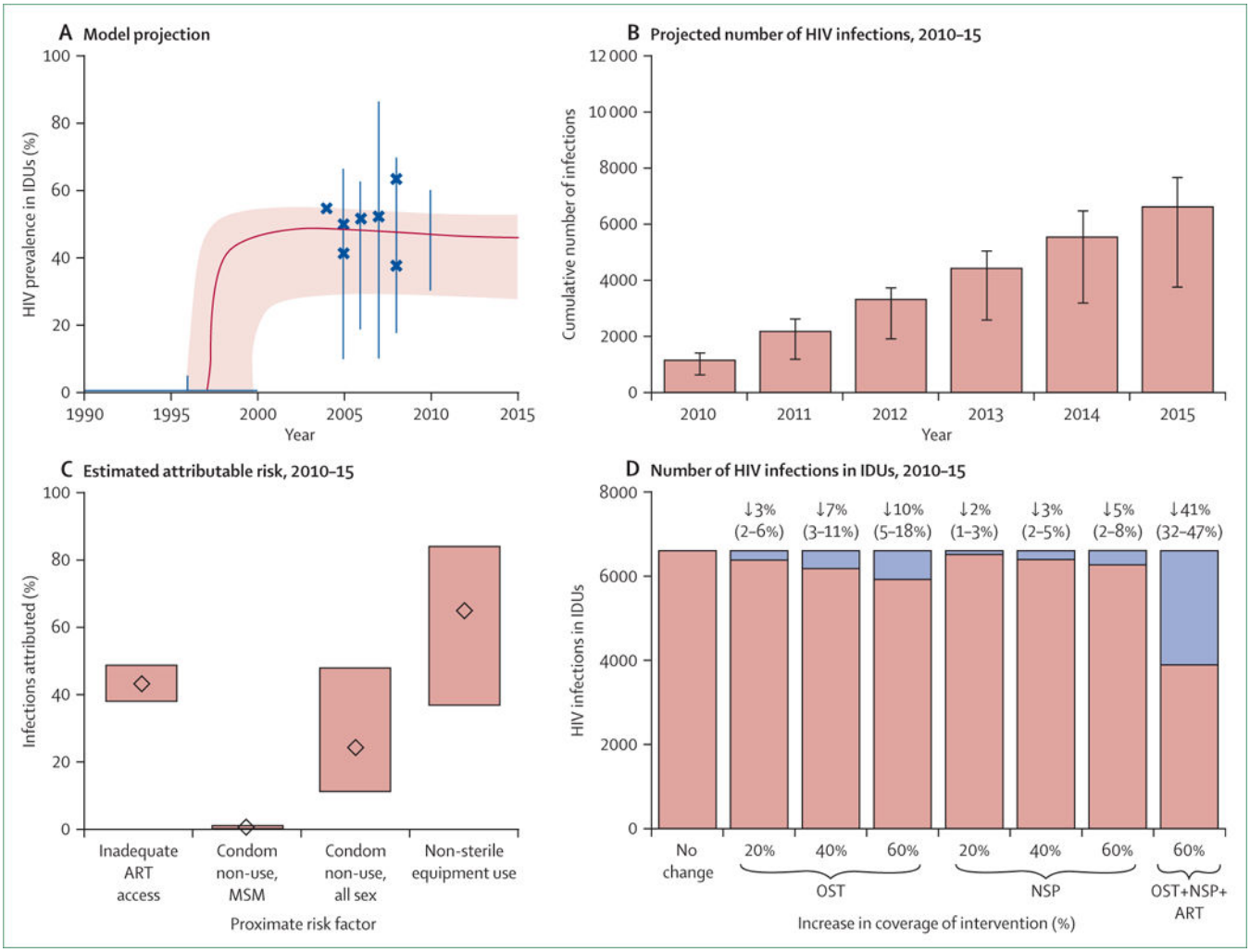

Figure 3: Model projections for the HIV epidemic in IDUs in Odessa, Ukraine

(A) HIV prevalence in IDUs, 1990–2015. Blue crosses show prevalence estimates from data; solid black lines show limits placed on HIV prevalence; pink area shows envelope of posterior model fits; and the thick red line shows the epidemic projection for the best-fitting model (for details of model and fitting procedure see webappendix pp 1–40). (B) Projected number of HIV infections every year for 2010–15 in the IDU population, assuming no further changes in patterns of risk (bars show best-fit estimate and vertical lines show 90% credible interval). (C) Estimates of the attributable risk of selected proximate risk factors for the IDU population. Estimates are the proportion of infections that would be averted in the absence of the risk factor, which is estimated as the proportion of projected infections that would be averted if that risk were absent from 2010–15; width of bar shows 95% credible interval and diamond shows median. Attributable risks do not sum to 100%. (D) Projected change in the number of HIV infections in Odessa (2010–15) and assuming increased coverage of OST, NSP, and ART by 20%, 40%, or 60%. Numbers (95% credible interval) are percentages of infections averted (shown in blue). Access to OST and NSP are assumed to reduce the rate of overall exposure to non-sterile injecting equipment by half, and present levels of access to interventions (table 1) are taken into account. IDUs=injecting drug users.

ART=antiretroviral therapy. MSM=men who have sex only with men. OST=opioid substitution therapy. NSP=needle and syringe programme.

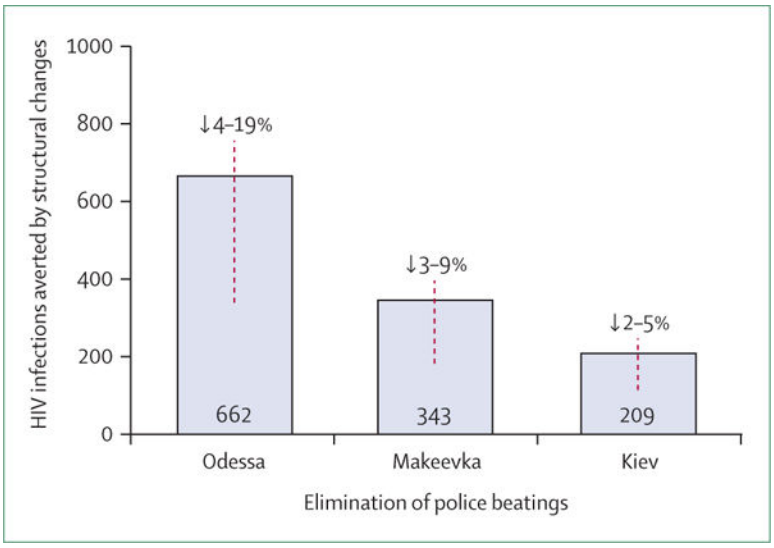

Figure 4: Estimated number of HIV infections averted by structural changes

Projected number (95% credible interval of percentage reduction) of infections that could be averted after elimination of police beatings in Odessa, Makeevka, and Kiev. Estimations made on the basis of reported correlations between exposure to non-sterile injecting equipment and experience of beatings in the three Ukrainian cities (see webappendix p 10).[99]

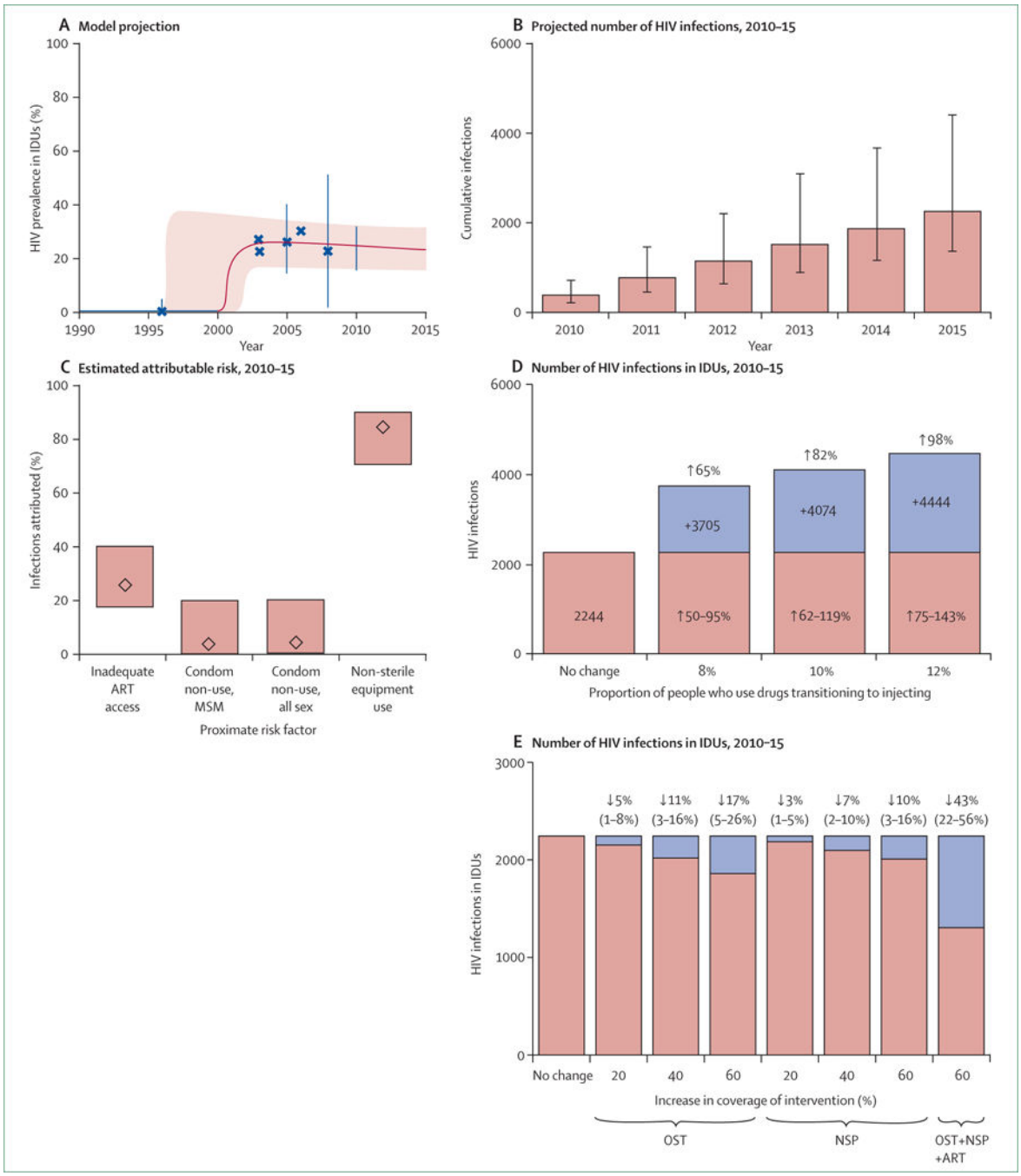

Figure 5: Model projections for the HIV epidemic in IDUs in Karachi, Pakistan

(A) HIV prevalence in IDUs, 1990–2015. Blue crosses show prevalence estimates from data; solid black lines show limits placed on HIV prevalence; pink area shows envelope of posterior model fits; and the thick red line shows the epidemic projection for the best-fitting model (for details of model and fitting procedure see webappendix pp 1–40). (B) Projected number of HIV infections every year for 2010–15 in the IDU population, assuming no further changes in patterns of risk (bars show best-fit estimate and vertical lines show 95% credible interval). (C) Estimates of the attributable risk of selected proximate risk factors for

the IDU population. Estimates are the proportion of infections that would be averted in the absence of the risk factor, which is estimated as the proportion of projected infections that would be averted if that risk were absent from 2010–15; width of bar shows 95% credible interval and diamond shows median. Attributable risks do not sum to 100%. (D) Projected number of infections in the IDU population during 2010–15, assuming that 8%, 10%, or 12% of people who use non-injecting drugs transition to injecting drugs in 2010. (for the model structure and variables see webappendix pp 1–40). (E) Projected change in the number of HIV infections in Karachi (2010–15) and assuming increased coverage of OST, NSP, and ART by 20%, 40%, or 60%. Numbers (95% credible interval) are percentages of infections averted (shown in blue). Access to OST and NSPs are assumed to reduce the rate of overall exposure to non-sterile injecting equipment by half, and present levels of access to interventions (table 2) are taken into account. IDUs=injecting drug users. ART=antiretroviral therapy. MSM=men who have sex only with men. OST=opioid substitution therapy. NSP=needle and syringe programme.

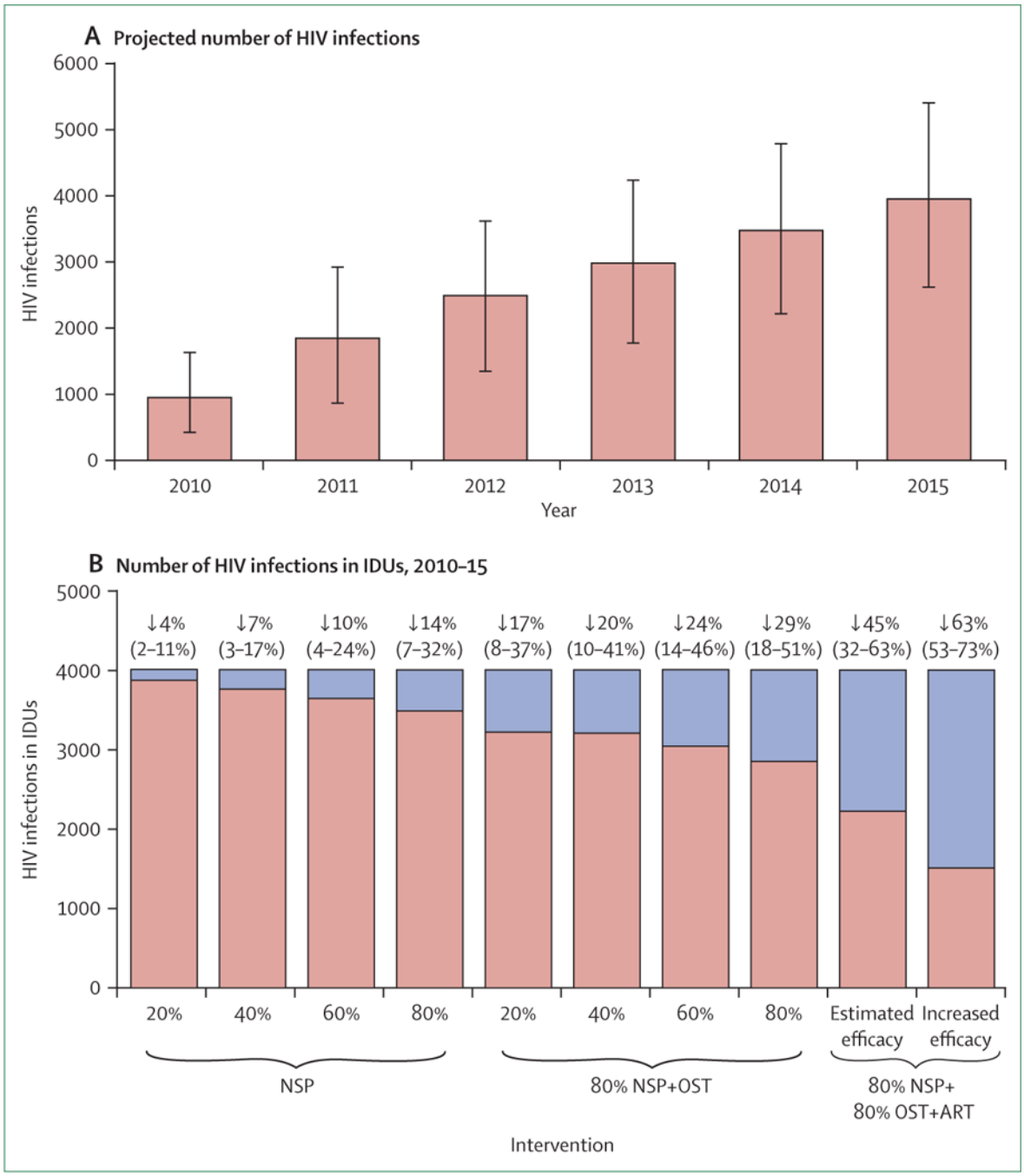

Figure 6: Model projections of the HIV epidemic in IDUs in Nairobi, Kenya

(A) Expected number of HIV infections (with 95% uncertainty interval) in IDUs in Nairobi, 2010–15. (B) Estimated effect of interventions on the total number of infections in IDUs, 2010–15. Red parts of the bars are proportion of infections averted relative to a no-intervention scenario. Interventions are 20%, 40%, 60%, or 80% coverage of NSPs; 80% coverage of NSPs plus 20%, 40%, 60%, or 80% coverage of OST; 80% coverage of NSPs and OST plus 80% coverage of antiretroviral therapy (initiated at CD4 count of 350 cells per μL) to those in need; and 80% coverage of NSTs and OST at a higher effectiveness (70%)

and ART. IDUs=injecting drug users. NSP=needle and syringe programme. OST=opioid substitution therapy. ART=antiretroviral therapy.

Table 1:

Key parameter estimates for injecting drug users in Odessa, Ukraine

	Estimate (range)	Source
Population size	17100 (8900–21 360)	Local report for USAID[94]
Male (%)		
2005	66.2%	Balakireva (2005)[95]
2007	78%	Balakireva (2007)[96]
2008	75.8%	Pohorila et al (2008)[97]
Mean duration of injecting drug use (years)		
2005	9 (1–37)	Balakireva (2005)[95]
2007	13 (1–46)	Balakireva (2007)[96]
2008	10 (1–40)	Pohorila et al (2008)[97]
Ever used non-sterile injecting equipment (%)		
2005	17.9%	Balakireva (2005)[95]
Past month, 2007	27.1%	Balakireva (2007)[96]
Past month, 2008	14.8%	Pohorila et al (2008)[97]
Men who have ever had sex with men (%)	2.4%	Balakireva (2005)[98]
Estimate of HIV-1 prevalence (%)		
2008	368%	Pohorila et al (2008)[97]
2009	53%	Booth et al (2009)[99]
Years of rapid epidemic spread	1990–2000	Rhodes et al (1999)[100]

Data are number (range) unless otherwise stated. Estimates and range are the mode and limits of the distribution of value allowed in the model analysis (see webappendix pp 7–9). Values are the principal parameters used in the mathematical models. USAID=United States Agency for International Development.

Table 2:

Key parameter estimates for injecting drug users in Karachi, Pakistan

	Estimate (range)	Source
Population size	9000 (7200–10 400)	National AIDS Control Programme[101]
Men (%)	97.5% (95–100%)	Estimate is mean value reported in Karachi;[102–104] minimum and maximum values are from reports for any city in Pakistan
Ever used non-sterile injecting equipment (%)	83% (18–94%)	Estimate is percentage of injecting drug users who reported ever use of non-sterile equipment in Karachi;[105] minimum value is percentage of those that reported use of used syringes at most-recent injection in Karachi;[106] maximum value is highest report for ever use in any city in Pakistan from review of the published work[50,107,108]
Men who have sex with men (%)	14% (11–50%)	Estimate is percentage of male injecting drug users in Karachi who reported sex with men in the past month;[106] minimum and maximum values are from reports for any city in Pakistan[101]
Injecting drug users receiving opioid substitution therapy, 2009 (%)	0%	Mathers et al[108]
Injecting drug users in needle and syringe exchange programmes, 2008 (%)	53.3% (10.6–53.3%)	Estimate is percentage of injecting drug users in Karachi who reported having obtained syringes from a drop-in programme;[101] across Pakistan in 2008, needle and syringe programme coverage was estimated at nine syringes exchanged per injecting drug user[109]
Injecting drug users receiving antiretroviral therapy, 2009 (%)	0.38% (0.36–0.43%)	Mathers et al[109]
HIV prevalence estimate, 2008 (%)	23.1% (19.0–27.2%)	National AIDS Control Programme[101]
Years of rapid epidemic spread	2003–04	Bokhari et al[106]

Data are number (range) unless otherwise stated. Estimates and range are the mode and limits of the distribution of value allowed in the model analysis (see webappendix pp 7–9).

Table 3:

Key parameter estimates for injecting drug users in Nairobi, Kenya

	Estimate (range)	Source
Population size	3000–5000	Estimate made on the basis that 60% of injecting drug users (3 500) were contacted by outreach workers by June, 2009; UNODC Regional Office for Eastern Africa[110]
Group (%)		Nairobi Outreach Services Trust UNODC Report on Contacts 2009[110]
Sex (female)	7%	
Female sex worker	12%	
Sex (male)	66%	
Men who have sex only with men	7%	
Men buying sex	8%	
Mean number of injections with non-sterile equipment per week	3.6 (1–6)	Range is 95% confidence interval. Shared needle and syringe use in Nairobi[110]
Baseline coverage of opioid substitution therapy, 2010	0%	UNODC Regional Office for Eastern Africa[109]
Baseline coverage of needle-exchange programmes, 2010	0%	UNODC Regional Office for Eastern Africa[109]
Injecting drug users receiving antiretroviral therapy, 2010	<1%	UNODC Regional Office for Eastern Africa[109]
Estimate of HIV-1 prevalence, 2010 (%)	33–50%*	Minimum value is the self-reported HIV-1 test result reported in the Nairobi Outreach Services Trust UNODC Report on Contacts, and is an average of January, to October, 2000;[110] maximum value is the reported HIV-1 prevalence in injecting drug users in Mombasa in 2004[111]

UNODC=United Nations Office on Drugs and Crime.

*49.5% of injecting drug users were HIV-1 positive in Kenya in 2004.[111] UNODC project data from June, 2009 (updated on a monthly basis), suggested that 30% of injecting drug users were HIV-1 positive.