

Cost-effectiveness of a police education program on HIV and overdose among people who inject drugs in Tijuana, Mexico



Javier A. Cepeda,^{a,*} Leo Beletsky,^{b,c} Daniela Abramovitz,^c Carlos Rivera Saldana,^c James G. Kahn,^d Arnulfo Bañuelos,^e Gudelia Rangel,^f Jaime Arredondo,^g Peter Vickerman,^h Annick Bórquez,^c Steffanie A. Strathdee,^c and Natasha K. Martin^{c,h}



^aDepartment of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

^bSchool of Law, Bouvé College of Health Sciences, Northeastern University, Boston, MA, USA

^cDivision of Infectious Diseases and Global Public Health, University of California, San Diego, CA, USA

^dPhilip R. Lee Institute for Health Policy Studies, University of California, San Francisco, CA, USA

^eIndependent Policing Consultant, Tijuana, Mexico

^fMexico Section, U.S.-Mexico Border Health Commission, Tijuana, Mexico

^gCanadian Institute for Substance Use Research, University of Victoria, BC, Canada

^hPopulation Health Science Institute, University of Bristol, UK

Summary

Background Incarceration is associated with drug-related harms among people who inject drugs (PWID). We trained >1800 police officers in Tijuana, Mexico on occupational safety and HIV/HCV, harm reduction, and decriminalization reforms (Proyecto Escudo). We evaluated its effect on incarceration, population impact and cost-effectiveness on HIV and fatal overdose among PWID.

Methods We assessed self-reported recent incarceration in a longitudinal cohort of PWID before and after Escudo. Segmented regression was used to compare linear trends in log risk of incarceration among PWID pre-Escudo (2012–2015) and post-Escudo (2016–2018). We estimated population impact using a dynamic model of HIV transmission and fatal overdose among PWID, with incarceration associated with syringe sharing and fatal overdose. The model was calibrated to HIV and incarceration patterns in Tijuana. We compared a scenario with Escudo (observed incarceration declines for 2 years post-Escudo among PWID from the segmented regression) compared to a counterfactual of no Escudo (continuation of stable pre-Escudo trends), assessing cost-effectiveness from a societal perspective. Using a 2-year intervention effect and 50-year time horizon, we determined the incremental cost-effectiveness ratio (ICER, in 2022 USD per disability-adjusted life years [DALYs] averted).

Findings Compared to stable incarceration pre-Escudo, for every three-month interval in the post-Escudo period, recent incarceration among PWID declined by 21% (adjusted relative risk = 0.79, 95% CI: 0.68–0.91). Based on these declines, we estimated 1.7% [95% interval: 0.7%–3.5%] of new HIV cases and 12.2% [4.5%–26.6%] of fatal overdoses among PWID were averted in the 2 years post-Escudo, compared to a counterfactual without Escudo. Escudo was cost-effective (ICER USD 3746/DALY averted compared to a willingness-to-pay threshold of \$4842–\$13,557).

Interpretation Escudo is a cost-effective structural intervention that aligned policing practices and human-rights-based public health practices, which could serve as a model for other settings where policing constitutes structural HIV and overdose risk among PWID.

Funding National Institute on Drug Abuse, UC MEXUS CONACyT, and the San Diego Center for AIDS Research (SD CFAR).

Copyright © 2024 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Keywords: Structural intervention; Law enforcement; HIV; Overdose; Modelling; Cost-effectiveness

The Lancet Regional Health - Americas
2024;30: 100679

Published Online 1
February 2024
<https://doi.org/10.1016/j.lana.2024.100679>

*Corresponding author.

E-mail address: jcepeda2@jhu.edu (J.A. Cepeda).

Research in context

Evidence before this study

We searched PubMed and Google Scholar for peer-reviewed and non-peer-reviewed economic evaluations of police education programs which included substance use outcomes, published between 2013 and 2023 using the following search terms (“cost-effectiveness” OR “cost-benefit” OR “economic evaluation”) AND (“police education” OR “police training” OR “law enforcement training” OR “law enforcement education” OR “law enforcement assisted diversion”) AND (“substance use” OR “drug use” OR “drug abuse”). We additionally reviewed references within systematic reviews identified from the search. Among the 571 results, we identified 14 studies that reported an economic evaluation within the context of police training. Five studies described training procedures and content, which mostly focused on mental health, crisis intervention, and overdose prevention. Most studies examined the costs of criminal justice outcomes only, with one including the cost of health-related outcomes, such as overdose, HIV, and HCV treatment costs. We identified one cost-effectiveness analysis of a law enforcement program designed to increase access to health services among substance-using populations—the Law Enforcement-Assisted Diversion (LEAD) program in King County, Washington, USA. This analysis found police diversion was cost-effective by reducing criminal legal system costs, modestly increasing healthcare costs, and averting overdose, HIV, and HCV transmission. However, LEAD interventions vary widely in their scope and content, so these findings have limited

generalizability, and the King County analysis took place in a setting where drug use was still criminalized.

Added value of this study

To our knowledge, this economic evaluation is the first to describe the impact and cost-effectiveness of a replicable human rights-based structural intervention aimed at aligning policing practices with public health in a setting with drug decriminalization. We leveraged parallel longitudinal cohort data from both people who inject drugs and police officers in Tijuana, Mexico to inform a mathematical model of HIV transmission and fatal overdose. The cost-effectiveness of the police training was determined by assessing the incremental cost-effectiveness ratio with the intervention versus a no-intervention counterfactual scenario and comparing it against a range of willingness-to-pay thresholds for Mexico. The intervention had a modest impact over a two-year period on HIV and overdose outcomes and was cost-effective and could be cost-saving if the training were developed and implemented by local investigators as opposed to U.S.-based.

Implications of all the available evidence

Findings indicate that police education can address important implementation gaps in drug law reform implementation and could be good value for money in Mexico. As efforts to reform counterproductive drug policies gather momentum, training police on evidence-based public health principles should be routinely adopted to reduce health harms that disproportionately affect people who inject drugs.

Introduction

In global settings, responses to drug use rely on punitive measures enforced by the criminal legal system.¹ In this context, street-level police behaviours targeting people who use drugs often conflict with evidence-based public health practice. People who inject drugs (PWID) have frequent encounters with the justice system, as evidenced by 58% reporting a history of incarceration.² The consequences of policing interactions with PWID have been extensively documented as structural determinants of infectious disease and other health risks.³ Further, these interactions can progress to incarceration, which is associated with elevated risks of HIV and hepatitis C virus (HCV) transmission and fatal overdose post-release.^{4–6}

Tijuana, Mexico is a large city situated along the U.S.-Mexico border characterized by structural determinants of infectious disease risk, such as policing behaviours fueling drug-related harms.^{7,8} Tijuana has public health significance on both sides of the border as an important destination for drug and sex tourism, which has resulted in fostering long-standing U.S.-Mexican collaborations to address binational public health concerns, such as HIV and drug use. Under the

banner of public health, the federal government reformed its General Health Law to decriminalize possession of small amounts of drugs in 2009.⁹ These reforms were also intended to increase access to substance use treatment in lieu of incarceration. However, a major gap in the implementation of these reforms reduced their street-level impact. This included low levels of knowledge among municipal police officers; only 11% of police officers in Tijuana correctly identified threshold amounts for heroin possession, six years after decriminalization.^{10,11} Subsequent analyses and modelling indicated the reforms were largely ineffective in reducing HIV incidence and expanding access to opioid agonist therapy (OAT).¹² To close this policy translation gap and better align policing with public health practice, a memorandum of understanding was established between U.S.-based researchers and the Tijuana police department to deploy a police education program (“Proyecto Escudo”, “Project Shield” [Eng.]) from February 2015 to May 2016.¹⁰ The Safety and Health Integration in the Enforcement of Laws on Drugs [SHIELD] model is an evidence-based intervention designed to reduce harmful police practices and increase behaviours that prevent bloodborne virus

transmission and support health of PWID. It recasts service referrals (e.g., to harm reduction services) as task-shifting, to reduce occupational burnout and stress. The training covered basic scientific and occupational safety knowledge related to injection equipment and infectious diseases, key policy elements of decriminalization, and content linking harm reduction programs to occupational benefits for police. Overall, the intervention significantly improved and sustained police-reported attitudes, knowledge, and behaviours regarding their interactions with PWID.^{13,14}

Despite one study evaluating the cost-effectiveness of a law enforcement diversion program in King County, Washington,¹⁵ no study has evaluated the population health-level and economic impact of a real-world police education intervention aligning policing with public health for substance-using populations in the context of drug decriminalization. Escudo presented a unique opportunity to assess the value for money of a human-rights and public health-oriented structural intervention in a setting where drug use was decriminalized. We hypothesized that Escudo would reduce incarceration and be cost-effective in preventing HIV transmission and fatal overdose among PWID in Tijuana, Mexico.

Methods

Overview

This analysis consists of epidemiological analyses, mathematical modelling, and economic evaluation of a police education program conducted in Tijuana, Mexico. Statistical analyses on incarceration trends were informed by primary data collected from a parallel longitudinal cohort of PWID in Tijuana, which was used to inform an adapted HIV transmission and overdose model.¹² We conducted a micro-costing of the intervention, and determined cost-effectiveness compared to a no intervention counterfactual.

Description of intervention

Intervention procedures of Escudo have been described previously.¹⁶ Briefly, didactic material aimed at reducing adverse practices like syringe confiscation and arrest for minor drug possession were developed in consultation with police leadership and piloted with officers. Trainings delivered by peer officers between February 2015 and May 2016 consisted of three hour-long modules. Overall, 1806 officers (approximately 80% of the police force) received the training. A random subsample of officers ($n = 771$) was followed semiannually for two years after the training and completed interviewer-administered questionnaires on attitudes and behaviours involving interactions with PWID.

Description of PWID cohort

Epidemiological data from the El Cuete prospective cohort study of PWID in Tijuana were used to assess

how incarceration patterns changed before, during, and after Escudo. Study details have been described previously.¹⁷ Briefly, eligibility criteria at baseline included injecting drugs in the past month, at least 18 years old, and not planning to move away from Tijuana. Participants were recruited by street outreach from March 2011 to May 2013 ($n = 734$) and followed-up until March, 2020 during which they completed semiannual interviewer-administered questionnaires on substance use, HIV, harm reduction, drug treatment services, and interactions with the justice system.

Statistical analyses of incarceration and drug treatment among PWID before and after Escudo

We hypothesized Escudo could have resulted in declines in recent incarceration among PWID in Tijuana due to correct knowledge of decriminalized thresholds. Therefore, the primary outcome examined for the intervention effect was self-reported incarceration in the past six months among El Cuete participants. This measure was constructed by whether PWID answered “yes” to if they had been in jail, prison or a detention centre, in the past 6 months. This analysis was limited to 666 participants who contributed 5142 study visits from March 2012 to March 2019 to be within three years of when the training started and ended. Some participants were lost-to-follow up during this period, but we found no significant difference between those lost or not lost to follow-up with respect to self-reported “incarceration ever” and “incarceration in the past 6 months” at baseline.

The exposure of interest was the calendar period, which was classified before, during, or after all police officers had received the training. Based on prior studies from Tijuana of factors associated with incarceration, we considered age, gender, years injecting drugs, ever deported, ever travelled to the U.S., homelessness, receptive syringe sharing in the past 6 months, and injected methamphetamine in the past 6 months as potential covariates in multivariable log-binomial modelling.⁴ In terms of exogenous factors that could have influenced incarceration, we included an indicator for the change in the ruling party of the local government which occurred in November 2016. We have previously documented how elections can influence police arrest frequencies, especially when a change in the ruling party occurs.¹⁸ Only calendar period, gender, receptive syringe sharing, and new government status were retained in the final model because they retained statistical significance or the model did not converge when the covariate was included.¹⁸

We used an interrupted time series (ITS) design and conducted segmented regression to model the linear trends in the log risk of incarceration over the pre and post-Escudo periods.¹⁹ First, data from surveys conducted between March 27, 2012 and March 15, 2019 were sorted chronologically by date of interview. Surveys conducted between March 24, 2015 and June 20, 2016

were excluded, as it was assumed that these surveys were conducted during the time the Escudo intervention was being scaled up (Escudo was implemented between February 28, 2015 and May 21, 2016). Then, for the remaining data, a “period” variable with 23 levels (each belonging to consecutive three-month periods) was created. The first 12 periods were considered to belong to the pre-Escudo time frame (between March 27, 2012 and March 23, 2015) and the 11 periods post-Escudo (between June 21st, 2016 and March 15, 2019).

To generate a mean log risk of incarceration for each period, we first conducted generalized linear mixed modelling using individual-level data and fit a multi-variable log-binomial model with an autoregressive (AR (1)) correlation structure to account for the correlation of repeated measures within each individual. We assessed autocorrelation by visually inspecting plots of the residuals against period and by conducting a Durbin–Watson test. Positive autocorrelation was detected. To determine whether the autocorrelation was only between adjacent time points or seasonal correlation was present, we also used stepwise autoregression with the first 5 lags (appropriate for checking seasonality for quarterly data). Of the lag terms, all lags except for lag 1 were eliminated. To estimate the intervention effect, we fit a linear regression model with a first-order autoregressive term and calculated the change in trend from pre-Escudo to post-Escudo to estimate the log risk of incarceration between each 3-month period during the post-Escudo period. Linear trends in log risk of incarceration within each period and the step level change between the pre-and post-Escudo periods are found in the [Supplementary Table S1A](#). A secondary ITS analysis limited to participants with at least one observation pre and post-training yielded nearly identical results ([Supplementary Table S1B](#)). All statistical procedures were conducted in SAS version 9.4.

Population impact and cost-effectiveness modelling

We estimated the population impact and cost-effectiveness of Escudo using a previously published dynamic, deterministic compartmental model of HIV transmission and overdose among PWID calibrated to HIV prevalence, incidence, and incarceration patterns in Tijuana.¹² The model included sexual and injecting-related transmission of HIV among PWID and incorporated recruitment onto antiretroviral therapy (ART) and OAT at a low, stable coverage.²⁰ We incorporated the impact of incarceration on elevated risk of syringe sharing (relative risk: 1.3, 95% CI: 1.2, 1.5) and overdose (relative risk: 1.7, 95% CI: 1.3–2.2).^{5,12} To estimate long-term costs and benefits, we modified the model to additionally track ex-PWID. As the intervention is hypothesized to affect injecting-related HIV transmission and overdose through its impact on incarceration exposure, the lack of data on Escudo effect on

incarceration patterns and overdose risk among ex-PWID meant we chose not to simulate any direct impact of the intervention on ex-PWID but tracked disease outcomes and costs among this group.

Calibration procedures of the model to pre-Escudo data (with stable incarceration trends) have been previously described ([Supplementary Table S2–S4](#) and [Supplementary Figure S1](#)).^{12,20} To incorporate parameter uncertainty, we sampled parameters from uncertainty distributions using Latin Hypercube Sampling, a form of stratified random sampling. 120,000 parameter sets were sampled, and 204 runs were selected which produced a log-likelihood about the 99th percentile. Most of the selected runs lay between the 95% confidence intervals of the calibration data. We now include this information in the main text and added figures in the supplement to show model fits to HIV prevalence and incidence by gender ([Supplementary Figure S1](#)). We calibrated the reduction in incarceration/reincarceration using an incarceration sub-model, calibrated to the results from the segmented regression ([Supplementary Figures S2 and S3](#)). No trend in incarceration was detected prior to Escudo.

Intervention scenarios

Scenario 1. No Escudo counterfactual: We simulated a counterfactual scenario assuming no Escudo implementation, with stable pre-Escudo incarceration rates as indicated by segmented regression analysis. Despite drug law reform, we assumed no change in incarceration or reincarceration after 2016.

Scenario 2. Observed intervention (2-year effect): We assumed a 2-year intervention effect of Escudo on reducing incarceration/reincarceration rates beginning in June 2016 (after all officers were trained), followed by a return to stable pre-Escudo levels. We based this on two factors: 1) police officers’ reported public health attitudes, knowledge, and behaviours involving interactions with PWID waned and then stabilized after 6 months after receipt of the training, remaining stable until the end of the two-year Escudo follow-up period among police¹³ and 2) Escudo was not integrated into the police training curriculum beyond 2018 so future impact is uncertain.

Cost-effectiveness analysis

We evaluated the cost-effectiveness of Escudo compared to a counterfactual of no-Escudo from a societal perspective, assuming a 2-year intervention effect and a 50-year time horizon. We costed the intervention using an ingredients-based approach (Refer to [Supplementary Material](#)).²¹ We included the economic costs of developing and implementing Escudo from the intervention provider perspective. We interviewed research personnel and reviewed program records and expenditure reports. All resources (e.g., personnel, developmental meetings, building space, officer time) were

monetized. For the cost-effectiveness analysis, we additionally include costs of incarceration and ART (at low stable coverage). In our base case, we neglect other disease-related costs, based on prior research indicating PWID did not access infectious disease-related care.²²

Health disutilities (decrements in quality of life) were attached to each health stage from the Global Burden of Disease Study to track disability-adjusted life years (DALYs).²³ All costs (2022 USD) and DALYs were discounted at 3% annually. We calculated the mean incremental cost-effectiveness ratio (ICER, mean incremental costs divided by mean incremental DALYs averted) for the intervention compared with the no Escudo counterfactual. We assessed costs-effectiveness compared to recommended willingness-to-pay (WTP) thresholds for Mexico of one times the per capita GDP (US\$8347 in 2020) or an opportunity-cost based WTP range (\$4842–\$13,557).^{24,25}

All modeling and cost-effectiveness analyses were conducted using MATLAB R2022a.

Sensitivity analyses

We conducted sensitivity analyses to assess the robustness of modelling assumptions. First, we substituted the costs of U.S.-based investigators with a hypothetical cost of Mexican counterparts implementing the intervention (Supplementary Table S5). We also assessed scenarios with no discounting, 6% discounting, reduced intervention effect using the upper bound of the relative risk of incarceration based on segmented regression ($RR = 0.33$), the inclusion of non-ART HIV disease stage costs²² (Supplementary Table S2), and a 10-year intervention effect with retraining costs 5 years after initial training. Finally, as HCV transmission could have also been impacted by the reduced incarceration, we included the additional benefit of Escudo on reducing HCV-associated DALYs derived from our separately published model.²⁶

Ethical approval

All participants in both Escudo and El Cuete provided informed consent. The Escudo study protocol was approved by the University of California San Diego (UCSD) Human Research Protections Program and Xochicalco University; El Cuete was approved by UCSD and El Colegio de la Frontera Norte (Tijuana).

Role of the funding source

This project was supported by funding from the National Institutes of Health (NIH). The NIH had no role in the study design, data collection, analysis, interpretation, writing of the report or decision to submit.

Results

Among PWID in Tijuana, the probability of recent incarceration was stable in the pre-Escudo period, however

significant declines were observed in the post-Escudo period (Fig. 1a). Based on segmented regression, the risk of incarceration between any two consecutive 3-month periods in the post-Escudo period was 21% lower than the corresponding risk during pre-Escudo (adjusted relative risk $aRR = 0.79$, 95% CI: 0.68, 0.91, $p = 0.005$) (Fig. 1b). While we found a 32% decline in the level change in probability of incarceration between the pre and post-Escudo periods, this change was not statistically significant ($p = 0.35$). We conducted an additional analysis treating time categorically due to potential concerns of violating the linearity assumption in the pre-Escudo period and the potential influence of the low probability of incarceration at the end of the post-Escudo period. We conducted log-binomial regression to compare the average risk of incarceration pre/post-Escudo and found a statistically significant reduction post-Escudo by 66% (Supplementary Table S6A). This was robust to the exclusion of the final two-time points of the post-Escudo and the first three time points of the pre-Escudo (Supplementary Table S6B). However, in doing so, we did not have sufficient number of time points within each period (12 recommended) to obtain reliable results for the ITS.

The calibrated epidemic model fit well to HIV incidence data in 2014. Although not used in the calibration, modelled estimates of HIV incidence by sex in the post-Escudo period were consistent with cohort estimates (Supplementary Figure S1). Based on a two-year intervention effect, we estimated Escudo prevented 1.7% [95% CI: 0.7–3.5%] of new HIV cases and 12.2% [95% CI: 4.5–26.6%] of fatal overdoses, compared to a counterfactual without Escudo (i.e. no reduction in incarceration) (Fig. 2).

The total cost of the intervention was USD 269,958, with an average unit cost of \$149 per officer trained (Supplementary Table S5). Planning and development costs (\$231,766) constituted 86% of the total intervention cost, while the remaining cost was attributed to implementation (\$38,192). Most of the intervention costs were due to personnel (\$222,582). Compared to the empirically derived estimate, if we hypothetically assumed local effort to implement the intervention, the cost would decline to \$40 per officer trained. The total two-year costs (ART, incarceration, intervention) with Escudo were 21% higher than the no Escudo counterfactual. However, intervention costs were offset by reduced incarceration costs, which declined by 84% with Escudo (Fig. 3). Assuming a 2-year intervention effect and a 50-year time horizon, Escudo resulted in a mean incremental cost-effectiveness ratio of \$3746 per DALY averted, cost-effective under both WTP thresholds (per capita GDP or opportunity-cost based WTP range) (Table 1). Approximately 55% and 90% of model runs were cost-effective at the lower bound threshold (\$4842) and upper bound (\$13,557) of the opportunity-cost-based WTP range, respectively (Supplementary Figure S5).

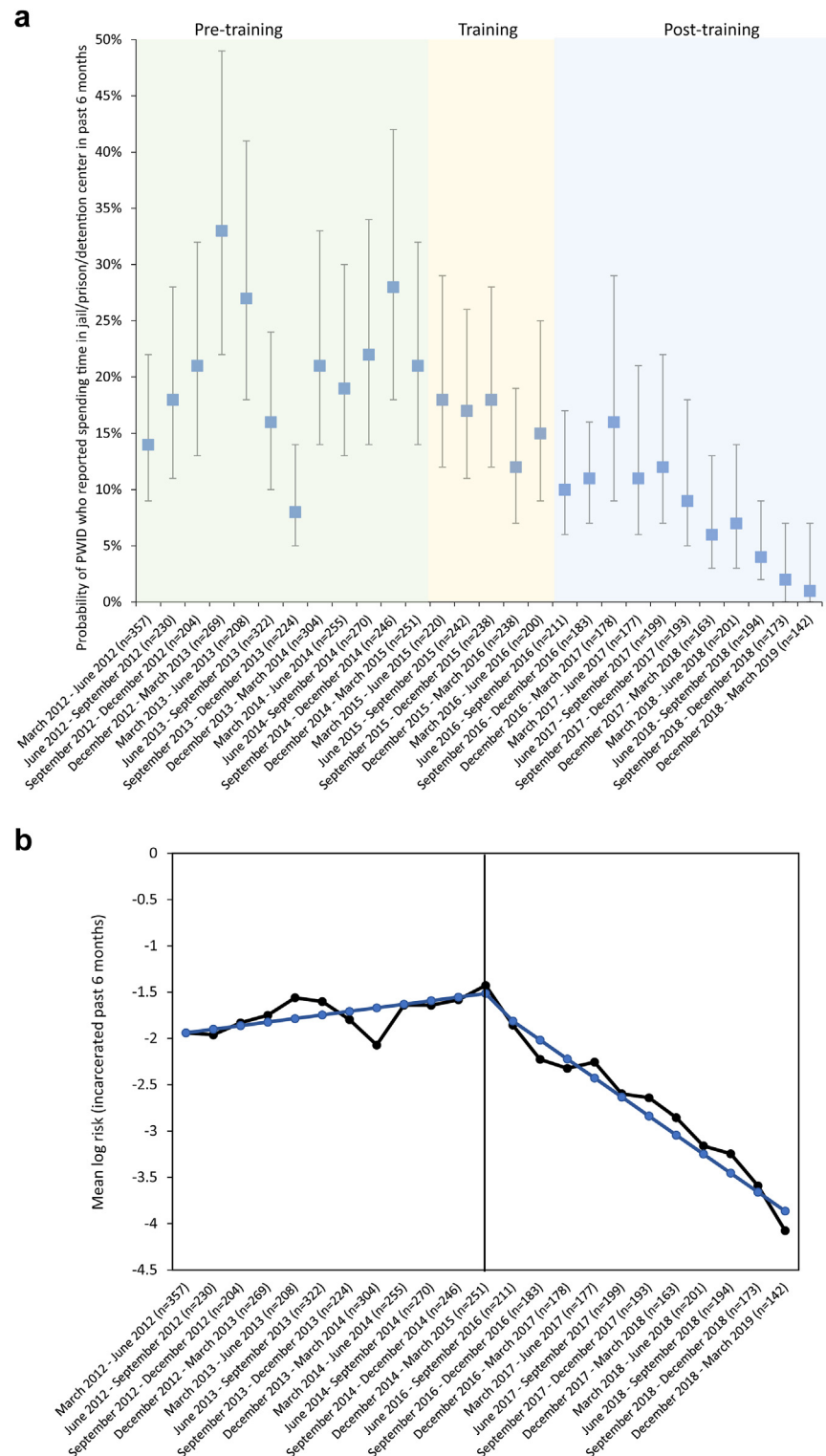


Fig. 1: (a) Probability of spending time incarcerated in the past 6 months among people who inject drugs in Tijuana, Mexico, March 2012–March 2019. (b) Mean log risk (black line) and structural model (blue line). Vertical line represents the change from the pre-to post-training period. Note: The training period is excluded.

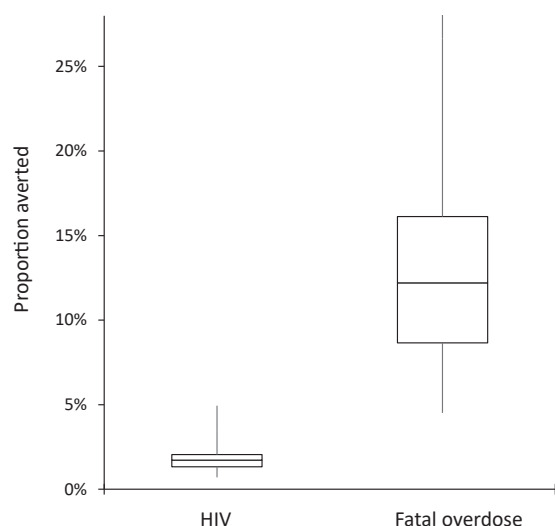


Fig. 2: Model-based results of the proportion of HIV and fatal overdoses averted among PWID in Tijuana two years after Escudo implementation.

The cost-effectiveness was most sensitive to the intervention effect estimate and discount rates (Fig. 4). Compared to the base case, the mean ICER increased to \$25,418 per DALY averted with a 6% discounting rate. With a lower Escudo intervention effect (using the upper bound of the relative risk in incarceration of 0.33), the ICER increased to \$8174 per DALY averted. There was minimal impact when including non-ART-related HIV costs. The ICER reduced with a 10-year intervention effect or when including HCV-related DALYs averted (\$1796 per DALY averted). Notably, the

intervention would be cost-saving with no discounting, or if the intervention development and implementation consisted of only local investigators (Table 1).

Discussion

Our findings are the first to articulate the value-for-money of a police education program aligning law enforcement practices with public health implemented in a decriminalized setting. We observed significant reductions in incarceration after the implementation of Escudo, which when simulated in our model, resulted in a modest impact on HIV and overdose-related mortality over two years. Further, Escudo was cost-effective compared to a counterfactual scenario where no public-health-oriented police training occurred. Despite the high upfront costs of police training, most costs were offset by reduced incarceration costs. Further, our sensitivity analyses revealed that if the intervention were developed and implemented by local personnel, it would have been cost saving.

Our findings are consistent with the larger body of evidence mostly from the U.S. that police training can improve knowledge, attitudes, and behaviors.^{27–29} For example, police in Louisville, Kentucky, received de-escalation training and significant declines in use-of-force, civilian, and officer injuries.²⁹ The impetus for Escudo was based on evidence that police in Tijuana (and likely elsewhere in Mexico) were not implementing the drug law reforms.^{9,18} If implemented correctly (with reduced incarceration and increased referral to OAT), our previous modelling indicated these reforms could have averted 9%–21% of new HIV cases over 12 years, more than our observed impact with Escudo because we

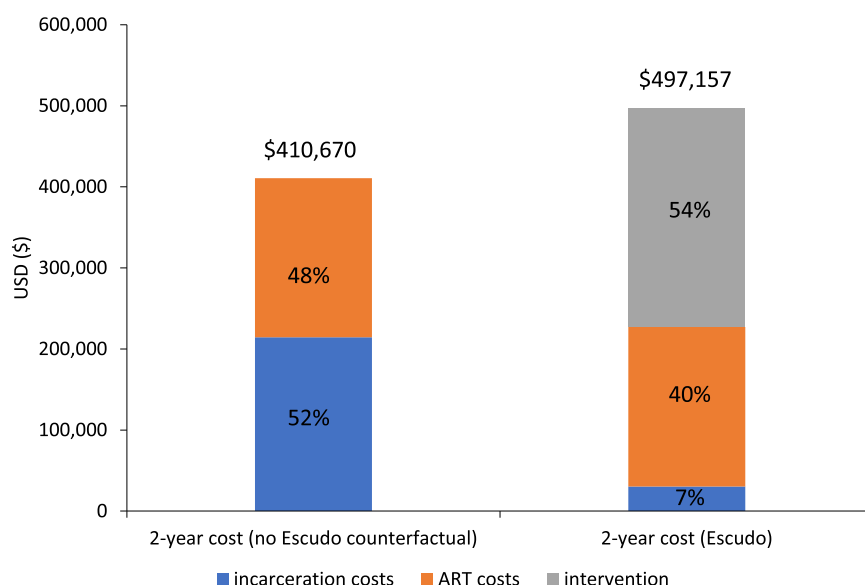


Fig. 3: Cost breakdown between no Escudo counterfactual and Escudo scenarios over the first two years of intervention (in USD \$).

	Total costs (2022 USD) mean (2.5–97.5 %ile)	Total DALYs mean (2.5–97.5 %ile)	Incremental costs (\$) mean (2.5–97.5 %ile)	Incremental DALYs averted mean (2.5–97.5 %ile)	Mean ICER (\$/per DALY averted) ^a	Mean number of HIV cases averted (2.5–97.5% ile)	Mean number of fatal overdoses averted (2.5–97.5% ile)
No Escudo counterfactual	597,742 (368,927–982,354)	25,406 (23,971–27,424)					
2-year effect (observed Escudo effect with international staff costs)	681,527 (545,606–893,879)	25,384 (23,957–27,380)	83,785 (–128,437, 208,943)	22.36 (6.50–60.71)	3746	1.34 (0.45–3.64)	18.52 (6.16–57.08)
2-year effect (observed Escudo effect with local staff costs)	488,134 (352,213–700,486)	25,384 (23,957–27,380)	–109,608 (–321,830, 15,550)	22.36 (6.50–60.71)	Cost saving	1.34 (0.45–3.64)	18.52 (6.16–57.08)
DALY: Disability Adjusted Life Year, ICER: Incremental Cost-Effectiveness Ratio. ^a Compared to No Escudo counterfactual.							

Table 1: Total costs, DALYs, and cost-effectiveness results comparing the no Escudo counterfactual and observed 2-year Escudo effect.

used a 2-year time horizon and did not observe changes in OAT.¹²

A novel aspect of Escudo was collecting follow-up data from police officers for two years after the intervention to monitor long-term effectiveness on knowledge and behaviours. Before training, only 11% of police officers correctly understood the decriminalized threshold for heroin possession and 37% were aware it was legal to possess syringes.^{10,11} This knowledge increased significantly after the intervention and was mostly retained until the end of follow-up.¹³ Further, officers were significantly less likely to have arrested individuals for heroin possession after Escudo compared to baseline levels, indicating that legal knowledge acquired from Escudo likely reduced behaviours associated with HIV and overdose risk (e.g., incarceration). The self-reported police data were consistent with statistical analyses which adjusted for both secular trends and potential confounders that could have contributed to the incarceration decline, such as change of the ruling political party in Tijuana—as law enforcement officials likely altered their policing based on the incoming administration's priorities.¹⁸ While we found that Escudo was cost-effective, the program was cancelled after a change in municipal leadership that occurred in 2017, while officers were in active follow-up. Since then, a more militarized approach was adopted which threatened the sustainability and long-term impact of the program. Nonetheless, supervisors in precincts with high drug use (and from where El Cuete participants were recruited) coordinated with local harm reduction organizations to provide refresher courses for officers patrolling these areas.

Global meta-analyses have characterized the immediate post-incarceration period as high risk for HIV and HCV transmission and overdose, indicating the need for structural interventions to reduce exposure of PWID to these environments.^{5,6} Our findings are consistent with an evaluation of a LEAD program in King County, Washington which found that diversion could increase uptake of community-based programs (syringe service, OAT, HIV treatment) and reduce HIV incidence by 3.4% and overdose by 10% over 10 years and was cost-effective.¹⁵ However our analysis addressed implementation gaps that led to a disconnect between policies and the lived experiences of PWID. Unlike the U.S. study, we did not simulate changes in receipt of OAT as coverage is very low (<5%) and unchanging in Mexico. Indeed, there are multiple structural barriers such as cost and availability³⁰ shaping OAT access specific to Mexico, recently exacerbated by the closure of Mexico's only methadone manufacturing plant.^{8,31} Thus, our findings are conservative given the additional impact police-initiated OAT referrals could have on overdose and HIV if achieved in other settings, given that we

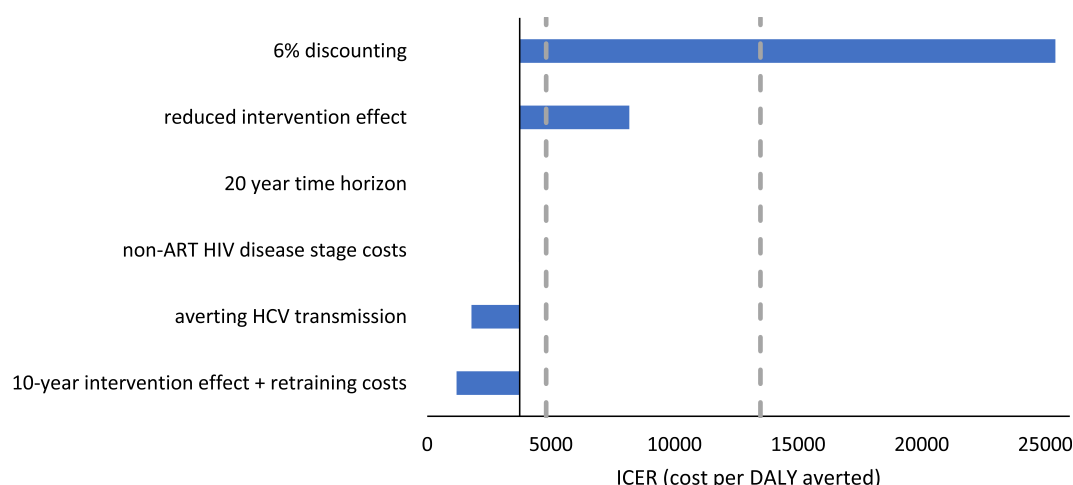


Fig. 4: Results from sensitivity analysis of the ICER. Scenarios which resulted in cost-savings are not shown (no discounting and intervention developed and implemented by local personnel). Solid black line represents ICER of the base case and dashed lines indicate lower and upper bounds of willingness to pay thresholds.^{24,25}

observed an increase in self-reported police referrals to health and social programs after receipt of Escudo.^{30,32} Unfortunately greater officer-reported referrals did not translate to changes in access among PWID due to limited OAT capacity in Tijuana.^{33,34} Our results are also consistent with other, more theoretical studies, examining the potential health and economic benefits of reduced incarceration on infectious disease and other health outcomes among PWID.^{1,6,12,35,36}

Our findings are subject to several limitations. Firstly, the impact of the intervention on structural-level policing practices is upstream from individual-level HIV and overdose risk, and the relationship between incarceration and these risks on which we based the modelling, might not be causal. As nearly all officers were trained, we could not follow an untrained group of officers as a comparison. However, even if such a group existed, controlling for contamination would have been difficult as officers rarely work alone and mixing of trained and untrained officers likely would have reduced effectiveness. Thus, we used segmented regression to assess the causal effects of the risk of incarceration within and between the intervention periods. However, we acknowledge that we were likely underpowered to detect a significant level change between the pre and post-Escudo periods.³⁷ Reforming police culture can take years to be adopted and routinely implemented³⁸ and this might be why we observed a change in the trend in incarceration but lacked detecting a significant level change between the pre and post-training periods. Secondly, we simulated the impact of Escudo through its effect on prison incarceration only, which we believe is conservative as there could be additional benefits of reducing short-term jail or detention centre exposure not captured in our analysis. Thirdly, our model did not

include data on people who use drugs but did not inject, who likely also would have benefited from the intervention. People who do not inject drugs are still susceptible to arrest and incarceration, which carries elevated overdose risk. Consequently, we may have underestimated cost-effectiveness as the impact on overdose might have been greater than what we were able to capture only in the El Cuete cohort.

Drug policy centred on the role of the criminal legal system to address drug use has been widely regarded as ineffective, yet carries high societal costs and shapes a risk environment that facilitates HIV and HCV transmission and overdose.¹ Punitive laws and their enforcement often serve as barriers to the implementation of effective public health measures. Reforming such laws is necessary, but often insufficient to achieve public health gains because of pervasive implementation gaps. Our study demonstrates that training street-level police to close policy implementation gaps and better align police practices with public health goals can yield a modest impact on HIV transmission and overdose over a 2-year period. Indeed, content in interventions like Escudo should be tailored to the specific drug and epidemic conditions to enhance generalizability. Police training like Escudo should be considered a core element of structural efforts to reduce drug-related harms, especially in settings with high substance use and where drug use has been decriminalized. Interventions like Escudo could be cost-effective and should be recommended by policymakers.

Contributors

JAC and NM conceptualized the analysis and wrote the first draft of the manuscript. SS and LB acquired funding to conduct the intervention and collect data. Statistical analyses were conducted by DA while

modeling and cost-effectiveness analyses were conducted by JAC, CRS, A. Bórquez, and NM. JA, GR, and A. Banuelos assisted with data collection and project administration. PV and JK provided technical assistance on modelling and cost-effectiveness analysis. All authors reviewed and edited the manuscript. JAC, NM, SS, LB, and DA directly accessed and verified the underlying data reported in the manuscript.

Data sharing statement

Data informing the epidemiological analyses from the El Cuete cohort are not publicly available. Inquiries related to these data should be directed to Daniela Abramovitz (dabramovitz@health.ucsd.edu). All parameters, calibration values, and equations in for the modeling are available in the manuscript and Supplementary Material.

Declaration of interests

JAC and SS report research grants from NIH. NM reports research grants from NIH and unrestricted research grants from Gilead and Abbvie unrelated to this work; and Leadership or fiduciary role for the International Network on Health and Hepatitis in Substance Users. All other authors declare no interests.

Acknowledgements

JAC received funding from the National Institute on Drug Abuse (K01DA043421); AB was funded for this work by National Institute on Drug Abuse (DP2DA049295, US–Mexico drug abuse prevention research fellowship, (R01DA037773, and R37A015612) and by the UC MEXUS CONACyT postdoctoral fellowship; SS and LB were supported by NIDA grant R01DA039073 and NM was funded by NIDA grants R01DA03773 and R01DA049644, NIAID/NIDA (R01AI147490), and the San Diego Center for AIDS Research (SD CFAR), an NIH-funded program (P30AI036214), which is supported by the following institutes and centers: NIAID, NCI, NHLBI, NIA, NICHD, NIDA, NIDCR, NIDDK, NIGMS, NIMN, NIMHD, FIC, and OAR.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.lana.2024.100679>.

References

- Csete J, Kamarulzaman A, Kazatchkine M, et al. Public health and international drug policy. *Lancet*. 2016;387(10026):1427–1480.
- Degenhardt L, Peacock A, Colledge S, et al. Global prevalence of injecting drug use and sociodemographic characteristics and prevalence of HIV, HBV, and HCV in people who inject drugs: a multistage systematic review. *Lancet Glob Health*. 2017;5(12):e1192–e1207.
- Baker P, Beletsky L, Avalos L, et al. Policing practices and risk of HIV infection among people who inject drugs. *Epidemiol Rev*. 2020;42(1):27–40.
- Rivera Saldana CD, Beletsky L, Borquez A, et al. Impact of cumulative incarceration and the post-release period on syringe-sharing among people who inject drugs in Tijuana, Mexico: a longitudinal analysis. *Addiction*. 2021;116(10):2724–2733.
- Merrall EL, Kariminia A, Binswanger IA, et al. Meta-analysis of drug-related deaths soon after release from prison. *Addiction*. 2010;105(9):1545–1554.
- Stone J, Fraser H, Lim AG, et al. Incarceration history and risk of HIV and hepatitis C virus acquisition among people who inject drugs: a systematic review and meta-analysis. *Lancet Infect Dis*. 2018;18(12):1397–1409.
- Pollini RA, Brouwer KC, Lozada RM, et al. Syringe possession arrests are associated with receptive syringe sharing in two Mexico–US border cities. *Addiction*. 2008;103(1):101–108.
- Werb D, Strathdee SA, Vera A, et al. Spatial patterns of arrests, police assault and addiction treatment center locations in Tijuana, Mexico. *Addiction*. 2016;111(7):1246–1256.
- Beletsky L, Wagner KD, Arredondo J, et al. Implementing Mexico's "Narcotráfico" drug law reform: a mixed methods assessment of early experiences among people who inject drugs. *J Mix Methods Res*. 2016;10(4):384–401.

- Cepeda JA, Strathdee SA, Arredondo J, et al. Assessing police officers' attitudes and legal knowledge on behaviors that impact HIV transmission among people who inject drugs. *Int J Drug Pol*. 2017;50:56–63.
- Arredondo J, Strathdee S, Cepeda J, et al. Measuring improvement in knowledge of drug policy reforms following a police education program in Tijuana, Mexico. *Harm Reduct J*. 2017;14:1–10.
- Borquez A, Beletsky L, Nosyk B, et al. The effect of public health-oriented drug law reform on HIV incidence in people who inject drugs in Tijuana, Mexico: an epidemic modelling study. *Lancet Public Health*. 2018;3(9):e429–e437.
- Baker P, Beletsky L, Garfein R, et al. Impact of SHIELD police training on knowledge of syringe possession laws and related arrests in Tijuana, Mexico. *Am J Public Health*. 2022;112(6):860–864.
- Beletsky L, Abramovitz D, Baker P, et al. Reducing police occupational needle stick injury risk following an interactive training: the SHIELD cohort study in Mexico. *BMJ Open*. 2021;11(4):e041629.
- Bernard CL, Rao IJ, Robison KK, Brandeau ML. Health outcomes and cost-effectiveness of diversion programs for low-level drug offenders: a model-based analysis. *PLoS Med*. 2020;17(10):e1003239.
- Strathdee SA, Arredondo J, Rocha T, et al. A police education programme to integrate occupational safety and HIV prevention: protocol for a modified stepped-wedge study design with parallel prospective cohorts to assess behavioural outcomes. *BMJ Open*. 2015;5(8):e008958.
- Robertson AM, Garfein RS, Wagner KD, et al. Evaluating the impact of Mexico's drug policy reforms on people who inject drugs in Tijuana, B.C., Mexico, and San Diego, CA, United States: a binational mixed methods research agenda. *Harm Reduct J*. 2014;11:4.
- Arredondo J, Gaines T, Manian S, et al. The law on the streets: evaluating the impact of Mexico's drug decriminalization reform on drug possession arrests in Tijuana, Mexico. *Int J Drug Pol*. 2018;54:1–8.
- Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther*. 2002;27(4):299–309.
- Cepeda JA, Bórquez A, Magana C, et al. Modelling integrated antiretroviral treatment and harm reduction services on HIV and overdose among people who inject drugs in Tijuana, Mexico. *J Int AIDS Soc*. 2020;23:e25493.
- Tan-Torres Edejer T, Baltussen R, Adam T, et al. *Making choices in health: WHO guide to cost-effectiveness analysis*. 2003.
- Bautista-Arredondo S, Dmytraczenko T, Kombe G, Bertozzi SM. Costing of scaling up HIV/AIDS treatment in Mexico. *Salud Pública de México*. 2008;50:S437–S444.
- Murray CJ. Quantifying the burden of disease: the technical basis for disability-adjusted life years. *Bull World Health Organ*. 1994;72(3):429–445.
- Woods B, Revill P, Sculpher M, Claxton K. Country-level cost-effectiveness thresholds: initial estimates and the need for further research. *Value Health*. 2016;19(8):929–935.
- Marquez LK, Fleiz C, Burgos JL, et al. Cost-effectiveness of hepatitis C virus (HCV) elimination strategies among people who inject drugs (PWID) in Tijuana, Mexico. *Addiction*. 2021;116(10):2734–2745.
- Rivera Saldana CD, Abramovitz D, Beletsky L, et al. Estimating the impact of a police education program on hepatitis C virus transmission and disease burden among people who inject drugs in Tijuana, Mexico: A dynamic modeling analysis. *Addiction*. 2023;118(9):1763–1774. <https://doi.org/10.1111/add.16203>.
- McLean K, Wolfe SE, Rojek J, Alpert GP, Smith MR. Randomized controlled trial of social interaction police training. *Criminol Publ Pol*. 2020;19(3):805–832.
- Campbell BA, Lapsey DS, Wells W. An evaluation of Kentucky's sexual assault investigator training: results from a randomized three-group experiment. *J Exp Criminol*. 2020;16:625–647.
- Engel RS, Corsaro N, Isaza GT, McManus HD. Assessing the impact of de-escalation training on police behavior: reducing police use of force in the Louisville, KY metro police department. *Criminol Publ Pol*. 2022;21(2):199–233.
- Burgos JL, Cepeda JA, Kahn JG, et al. Cost of provision of opioid substitution therapy provision in Tijuana, Mexico. *Harm Reduct J*. 2018;15(1):1–8.
- Werb D, Wagner K, Beletsky L, Gonzalez-Zuniga P, Rangel G, Strathdee S. Police bribery and access to methadone maintenance therapy within the context of drug policy reform in Tijuana, Mexico. *Drug Alcohol Depend*. 2015;148:221–225.

- 32 Cepeda JBL, Abramovitz D, Borquez A, Strathdee S, Martin N. *Evaluating the epidemiological impact of a police education program among people who inject drugs in Tijuana, Mexico*. San Diego, USA: College on Problems of Drug Dependence; 2018.
- 33 MacArthur GJ, Minozzi S, Martin N, et al. Opiate substitution treatment and HIV transmission in people who inject drugs: systematic review and meta-analysis. *BMJ*. 2012;345:e5945.
- 34 Sordo L, Barrio G, Bravo MJ, et al. Mortality risk during and after opioid substitution treatment: systematic review and meta-analysis of cohort studies. *BMJ*. 2017;357:j1550.
- 35 Ward Z, Stone J, Bishop C, et al. Costs and impact on HIV transmission of a switch from a criminalisation to a public health approach to injecting drug use in eastern Europe and central Asia: a modelling analysis. *Lancet HIV*. 2022;9(1):e42–e53.
- 36 Stone J, Martin NK, Hickman M, et al. Modelling the impact of incarceration and prison-based hepatitis C virus (HCV) treatment on HCV transmission among people who inject drugs in Scotland. *Addiction*. 2017;112(7):1302–1314.
- 37 Zhang F, Wagner AK, Ross-Degnan D. Simulation-based power calculation for designing interrupted time series analyses of health policy interventions. *J Clin Epidemiol*. 2011;64(11):1252–1261.
- 38 O'Neill WG. *Police reform in post-conflict societies: what we know and what we still need to know*. New York: International Peace Academy; 2005.