Recovering Infectious HIV from Novel Syringe–Needle Combinations with Low Dead Space Volumes

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Abstract

This study determines if detachable syringe–needle combinations redesigned to reduce their dead space volume may substantially reduce the burden of exposure to infectious HIV among people who inject drugs. Two novel, low dead space (LDS) syringe–needle designs—one added a piston to the plunger (LDS syringe) and the other added a filler to the needle (LDS needle) to reduce their dead space—were compared to standard detachable needle–syringe combinations and to syringes with fixed needles. LDS and standard syringes attached to LDS and standard needles of 23-, 25-, and 27-gauge size were contaminated with HIV-infected blood in the laboratory. The proportion of syringe–needle combinations containing infectious HIV was analyzed after syringes were (1) stored up to 7 days at 22°C or (2) rinsed with water. Detachable syringes attached to 25-gauge needles yielded comparable proportions of syringes with infectious HIV, whether the needle was standard or LDS. Among needles of greater diameter (23 gauge), LDS needles tended to reduce recoverable HIV to a greater extent than standard needles. Syringes with fixed needles showed superior results to LDS syringes attached to needles of equivalent diameter and were less likely to get clogged by blood. Detachable LDS syringe–needle designs must be recommended with caution since they still pose potential risk for HIV transmission. Distribution of LDS syringes and needles must be accompanied by recommendations and instructions for their proper rinsing and disinfection in order to reduce viral burden and chances of needle clogging.

Keywords: infectious HIV, low dead space syringes, injection drug use, syringe rinsing, syringe clogging, HIV viability

Introduction

PEOPLE WHO INJECT DRUGS account for 30% of new HIV infections outside sub-Saharan Africa.¹ In Eastern Europe and Central Asia, a region where HIV incidence is rising, national HIV epidemics are typically driven by the use of HIV-contaminated syringes and HIV-contaminated equipment during drug injection.¹ Epidemiological interventions are currently focused on reducing the reuse of syringes and increasing access to sterile syringes for the intravenous injection of illicit drugs.² Contamination of syringes with HIV usually occurs at the time of injection when the needle is inserted into the vein and blood is aspirated into the syringe to assure that the needle is correctly placed in the vein.³ Once a syringe becomes contaminated, it will remain so until it is safely discarded or disinfected or the virus becomes inactive as a consequence of age.

In the United States, the most common syringe in use is a 1 cc insulin syringe with a needle permanently attached⁴; these single piece needles and syringes hold $\sim 2 \mu\text{L}$ of blood when the plunger is completely depressed.⁵ In many other countries and in locations where pharmaceuticals are injected, by contrast, syringes with 2 cc or larger barrel vol-

umes and removable needles are the equipment of choice because they allow for replacement of the needle without having to replace the syringe.

In addition to extending the life of the syringes, detachable syringes provide a number of advantages for drug preparation and injection. People who inject larger volumes may require bigger syringes and heavier gauge needles. Larger syringe volumes are necessary for the injection of certain drugs, including homemade drug mixtures, viscous liquids such as steroids, and dissolved pharmaceuticals.^{6,7} Larger needle sizes and lengths, which are available only for detachable syringes, allow for access to deeper veins or intramuscular injection.⁶ Finally, detachable needles allow for the possibility of needle replacement should clogging or dulling occur.⁶

The detachable needle configuration, however, may prove riskier for HIV transmission because the larger dead space volume allows for more blood to be retained between the plunger and the tip of the needle compared to the insulin syringes with fixed needles.⁵ Previous simulation studies with syringes showed proportions of 8% of HIV positive syringes after 13 days, among syringes harboring $2 \mu\text{L}$ residual blood, and 17% among syringes retaining $20 \mu\text{L}$ residual blood.⁸ Therefore, the development of strategies to

reduce dead space volumes of detachable syringe–needle configurations may prove to be a useful method to reduce the transmission of blood-borne diseases such as HIV.

To reduce the risk of HIV transmission through the reuse of syringes, two providers of injection equipment for syringe exchange programs have developed detachable needle–syringe combinations that reduce their dead space volumes.⁶ Each of them used a different approach. The British firm Exchange Supplies⁹ uses a modified needle constructed with molded plastic that fills the connecting part of the needle. The French firm Apothicom¹⁰ added a piston to the end of the plunger to fill the syringe hub to which the needle is attached. Encouraging people who inject drugs to use these novel, low dead space (LDS) syringes and needles requires the demonstration that their use could result in relatively less exposure to infectious HIV comparable to insulin syringes, the currently available option with the lowest dead space.

We conducted this study to test these two syringe prototypes for their ability to retain infectious HIV and compared them to standard detachable needle–syringe pairs and to insulin syringes¹¹ with fixed needles. This study uses a microculture assay capable of propagating HIV from small volumes recovered from used syringes to determine the percentages of syringes yielding infectious HIV (1) during storage at room temperature for up to 7 days and (2) following one or two rinses of the syringes with water.

Testing HIV recovery from these novel syringe–needle designs will allow us to advise the manufacturers, suppliers, and harm reduction programs, such as needle exchanges, on the value of the redesigned detachable needle–syringe combinations and make a recommendation on whether one combination is better than the other. We have already published our results for the retention of hepatitis C virus (HCV).⁵ However, HIV and HCV differ in infectiousness and survival rates in syringes, with higher rates for HCV than for HIV.^{12,13} Thus, despite the benefits that knowledge about HCV survival in syringes may provide, specific information on the degree and duration of HIV infectiousness is needed.

Materials and Methods

Preparation of virus stocks and HIV-infected blood

These methods have been described in detail elsewhere.¹⁴ In summary, wild-type clinical isolates of HIV were prepared from coculture of lymphocytes gathered from HIV-1-infected patients and fresh stimulated peripheral blood mononuclear cells from uninfected individuals. Virus stocks comprised the harvested supernatants, which were aliquoted without being centrifuged or filtered and were stored at -70°C until use. For laboratory simulations, HIV-infected blood was prepared by combining blood from healthy, uninfected blood donors with one of two stocks of HIV-1 at a ratio of $\sim 20:1$ and incubating the mixture overnight at 37°C before use. This study was approved by the Institutional Review Board of Yale University (New Haven, CT).

Preparation of syringes

The syringes were handled in the laboratory to simulate common illicit drug injection practices.³ When injecting into veins, the user locates a vein and inserts the needle. To determine that the syringe is within the vein, the injector draws back

to make sure that blood flows into the syringe. This process has been termed “registering.” After the drug solution has been injected, injectors often keep the needle in the vein and refill the syringe with blood. The blood is then reinjected and the needle is withdrawn from the vein. This process has been termed “booting.”^{15–17} “Booting” represents a worst-case scenario because what is left in the syringe is almost entirely the injector’s blood.

In preparing the syringes, the process of “booting” was simulated. Thus, in our experiments, HIV-infected blood was drawn into the barrel of the syringes (through their fixed or attached needles) and the plunger was then fully depressed, yielding volumes found in syringes commonly reused by people who inject drugs in most parts of the world.

Detection of infectious HIV inside syringes

HIV titers will affect the rate of recovery of infectious HIV from syringes and needles.^{14,18,19} Therefore, we controlled for variations in HIV titers between experiments by testing all seven syringe–needle combinations simultaneously within each experiment. Results could then be compared within each experiment ensuring that comparisons were made between syringe–needle combinations that had been prepared with the same HIV-infected blood with the same virus titers, tested in cell cultures originated from the same blood donors, and handled under similar laboratory conditions. To facilitate handling, each experiment tested small sets of 10 syringe–needle combinations per condition and experiments were repeated until the desired number of 30 syringe–needle combinations per condition was reached.

Comparisons were made among four main types of needle–syringe combinations: (1) insulin syringes with fixed needles,¹¹ (2) Noloss syringes, a detachable syringe in which a piston is added to the end of the syringe plunger to reduce its dead space volume,⁹ (3) Nevershare syringes, a detachable syringe prototype attached to a Total Dose (LDS) needle constructed with molded plastic that fills the connecting part of the needle and reduces its dead space volume,¹⁰ and (4) Nevershare syringes attached to standard needles. Figure 1 shows the three types of syringes and two types of needle designs used in this study.

We tested for HIV infectivity immediately after syringes (including their fixed or attached needles) were contaminated with HIV-infected blood, after storage for up to 7 days at room temperature or after being rinsed once or twice with sterile distilled water as described in previous studies.^{5,8,20} Rinsing with water consisted of loading the syringes up to approximately half the volume marked on the syringe barrel, that is, 2 ml syringes were rinsed with 1 ml of water and 1 ml syringes were rinsed with 0.5 ml of water.

To detect the presence of infectious HIV inside syringes, the contents remaining in the dead space of the syringe–needle combinations were extracted with 100 μl aliquots of cell culture media, which were introduced into wells in 96-well tissue culture plates containing 100 μl of stimulated peripheral blood mononuclear cells as targets for HIV infection and replication. Cultures were maintained for 3 weeks. Cell culture supernatant was removed and fresh peripheral mononuclear blood cells were added to each well on a weekly basis. HIV infectivity was determined by the presence of detectable HIV p24 antigen in the cell culture

FIG. 1. The three types of syringes and two types of needle designs used in this study. (A) Insulin (left), Nevershare (middle), and Noloss (right) syringes. (B) LDS (left) and standard (right) needles. LDS, low dead space.

wells at the end of 3 weeks (XpressBio HIV-1 P24 Assay; XpressBio Life Science Products, Frederick, MD).

Statistical analyses

The results are reported as the number and percentages of syringes that yielded infectious HIV, that is, HIV-positive syringes. Comparisons were made between syringe–needle combinations with similar needle lengths and gauges. Proportions of HIV-positive syringes were compared by chi-square or Fisher's exact tests. Statistical calculations were done with SPSS Statistics version 19 for PC.

Results

Number of syringe–needle combinations tested for infectious HIV

The data presented in this report were obtained from six discrete experiments conducted between July 2014 and September 2015 testing seven syringe–needle combinations. Table 1 provides a detailed description of each syringe–needle combination and the abbreviations used to define them in this article. In total, 1,470 syringes were “loaded” with HIV-contaminated blood for testing. The titer of the HIV-contaminated blood varied in each experiment and ranged from ~20 to 16,800 infectious units of HIV per ml of blood.²¹

Among the 1,470 syringes, 420 positive syringe controls (10 syringes per combination tested, six experiments) were tested immediately after preparation without being rinsed. Among the 415 tested positive controls, 350 (84%) yielded infectious HIV, a rate similar to previous syringe simulation experiments with infectious HIV.⁸

Number of untested syringes due to clogging

A total of 98 (7%) syringes could not be tested because their needles became clogged by blood (percentage untested in Table 1).

TABLE 1. NUMBER OF SYRINGE–NEEDLE COMBINATIONS TESTED FOR INFECTIOUS HIV (N=1,470)

Syringes	Needles ^a	No. of syringes loaded with HIV-infected blood ^b	Relative volume of liquid retention ^c (μl)	No. of syringes tested (%)	Untested (%)
2 ml Noloss ^d	23-gauge 1¼" standard (23std) ^e	210	17.8 ± 4.5	204	3
	25-gauge ⅝" standard (25std) ^e	210	17.4 ± 2.5	197	6
	27-gauge ½" standard (27std) ^e	210	13.9 ± 1.9	178	15
2 ml Nevershare [®] , ^f	23-gauge 1¼" Total Dose [™] (23LDS) ^g	210	Not tested	200	5
	23-gauge 1¼" standard (23std) ^e	210	16.7 ± 1.8	195	7
	25-gauge ⅝" Total Dose (25LDS) ^g	210	17.0 ± 3.2	190	10
1 ml Insulin ^h	27-gauge ½" fixed to insulin syringe	210	1.3 ± 0.5	208	1
Total		1,470		1,372	93

^aThe higher the gauge, the smaller the inner diameter of the needle bore (23), therefore, the order of bore diameters was, from largest to smallest: 23, 25, and 27 gauge.

^bNinety syringes for rinsing experiments and 120 syringes for longevity experiments.

^cAccording to Binka *et al.*⁵

^dNoloss LDS syringes (Apothicom, Paris, France).

^ePrecisionGlide[™] standard needles (Becton Dickinson, Franklin Lakes, NJ).

^fNevershare syringes (Exchange Supplies, Dorchester, United Kingdom) specifically designed to attach to Total Dose LDS needles (Exchange Supplies).

^gTotal Dose LDS needles (Exchange Supplies)—only attachable to Nevershare and not to the Noloss syringes tested in this study.

^h1 ml U-100 insulin syringes with fixed 27-gauge ½" needles (Terumo Med, Piscataway, NJ).

LDS, low dead space.

FIG. 2. Reduction in number of syringes tested due to clogging of needles by whole blood.

A significant difference in the percentage of clogged/untested needles was found between two syringe-needle combinations: (1) Nevershare syringes (which are designed to attach to LDS needles) attached to standard 23-gauge standard needles (Nevershare-23std) were more likely to get clogged compared to Noloss-23std (7% vs. 3%, chi-square 4.0, 1, $p = .044$) and (2) syringes with fixed needles were less likely to get clogged than were detachable syringe-needle combinations (Noloss 27std = 15% vs. insulin = 1%, Fisher's exact test 28.8, 1, $p < .001$) (Fig. 2).

The proportion of clogged syringes did not significantly differ among all other combinations tested: Noloss-23std versus Nevershare-23LDS = 3% versus 5%, $\chi^2 = 1.0$, $p = .308$;

Nevershare-23LDS versus Nevershare-23std = 5% versus 7%, $\chi^2 = 1.1$, $p = .302$; and Noloss-25std versus Nevershare-25LDS = 6% versus 10%, $\chi^2 = 1.6$, $p = .204$.

Recovery of infectious HIV after up to 7 days storage and after syringe rinses with water

As expected, the overall number of syringes testing positive for infectious HIV declined in direct proportion to the length of time syringes were stored and the number of times syringes were rinsed. These results were observed among all syringe-needle combinations tested (Fig. 3).

FIG. 3. Recovered infectious HIV from syringes.

TABLE 2. TOTAL HIV-POSITIVE SYRINGES

	Longevity experiments (% of total positive syringes obtained at day 0, 1, 3, and 7)			Rinsing experiments (% of total positive syringes obtained after 0, 1, and 2 rinses)		
	%	χ^2	p	%	χ^2	p
Noloss-23std vs. Nevershare-23std	86 vs. 85	0.06	.801	61 vs. 46	4.7	.029
Noloss-23std vs. Nevershare-23LDS	86 vs. 68	10.1	.002	61 vs. 37	11.3	.001
Nevershare-23LDS vs. Nevershare-23std	68 vs. 85	8.2	.004	37 ^a vs. 46	1.5	.226
Noloss-25std vs. Nevershare-25LDS	79 vs. 71	1.5	.213	52 ^a vs. 49	0.2	.655
Insulin vs. Noloss-27std	61 vs. 78	7.9	.005	22 vs. 59 ^a	23.9	<.0001

^aNote that the percentage of infectious HIV recovery did not significantly differ or was greater as the needle diameters of detachable syringe-needle combinations increased, with the exception of Nevershare-23LDS, which yielded significantly lower percentage of infectious HIV than Noloss-25std (37% vs. 52%, χ^2 4.4, $p=.036$) and Noloss-27std (37% vs. 59%, χ^2 7.64, $p=.008$) in the rinsing experiments. These differences were not significant in the longevity experiments.

Increasing the length of storage time substantially decreased the recovery of infectious HIV so that syringes tested on day 7 contained the lowest proportion of HIV-positive syringes compared with syringes tested on days 0, 1, and 3. Similarly, increasing the number of rinses substantially decreased the recovery of infectious HIV so that twice rinsed syringes contained a lower proportion of HIV-positive syringes compared with unwashed or once washed syringes.

Comparing syringes attached to 23-gauge needles

Noloss-23std and Nevershare-23std combinations yielded similar proportions with infectious HIV in longevity experiments (86% vs. 85%, $p=.801$). In rinsing experiments, Nevershare-23std yielded significantly less recoverable infectious HIV than Noloss-23std (62% vs. 46%, $p=.029$) (Table 2).

Noloss-23std yielded a significantly greater number of HIV-positive syringes compared to Nevershare-23LDS in longevity and in rinsing experiments (86% vs. 68%, $p=.002$ and 62% vs. 37%, $p=.001$; respectively).

Nevershare-23LDS yielded a lower number of HIV-positive syringes compared to Nevershare-23std, and the difference was significant in the longevity experiments but not in the rinsing experiments (68% vs. 85%, $p=.004$ and 37% vs. 46%, $p=.226$, respectively).

Figure 4 shows an overall summary of the results of syringes attached to 23-gauge needles.

Comparing syringes attached to 25-gauge needles

No significant difference was observed in the recovery of infectious HIV from Noloss-25std and Nevershare-25LDS in both the longevity (79% vs. 71%, $p=.213$) and rinsing experiments (52% vs. 49%, $p=.655$).

Comparing syringes attached to 27-gauge needles

Syringes with fixed needles yielded fewer HIV-positive syringes than the detachable LDS syringe-needle combination in all the longevity (61% vs. 78%, $p=.005$) and the rinsing experiments (23% vs. 59%, $p<.0001$).

Discussion

Our results show that the detachable LDS syringe-needle designs retained comparable levels of infectious HIV, independent of the needles being standard or LDS. However, a considerable improvement was seen when LDS rather than the standard needles were used among syringes with 23-gauge needles, which have larger diameters and therefore harbor more blood than 25-gauge needles.

All of the detachable combinations yielded a higher proportion of syringes with infectious HIV than the syringes with fixed needles, consistent with results of parallel studies with HCV-contaminated syringes.⁵

It was interesting to find a lower likelihood of infectious HIV recovery from syringes with 23- rather than 25- and 27-gauge needles in the rinsing experiments, given that one would expect to find a greater rather than lower percentage of HIV recovery as the needle diameters of detachable syringe-needle combinations increased and given that this phenomenon was seen only in the rinsing experiments. This could be explained by a few factors. The 23-gauge needles tested in this study were longer than the 25-gauge (1¼" vs. ⅝", respectively) and the 27-gauge (1¼" vs. ½", respectively) needles. It could be that the greater needle length enhances the mechanical sheering effect that disrupts viral particles and reduces infectivity as the contaminated blood passes through the needle during rinsing. This might become more evident as the number of rinses increases and is perhaps enhanced by the LDS syringe-needle design.

FIG. 4. Summary of 23-gauge needle results.

Our comparisons revealed a syringe–needle combination (e.g., Nevershare-23LDS vs. Nevershare-23std) that yielded significantly lower levels of viable HIV after syringes were stored but no significant difference after syringes were rinsed. Another combination (e.g., Nevershare-23std vs. Noloss-23std) yielded significantly lower levels of HIV after syringe rinsing but not after syringe storage. This difference might be explained by the interaction of blood density/viscosity and the configuration of the design used to lower the dead space. For example, certain designs might prevent the viscous blood from drying inside the dead space thereby facilitating the retention of HIV viability in longevity experiments. Conversely, blood density/viscosity could interact with the LDS design to reduce the effectiveness of water rinsing, thereby yielding syringes that are more likely to test positive for HIV after rinsing but not after storage.

Our results showed a marked reduction in the recovery of infectious HIV due to syringe–needle rinsing with water. This finding supports previous observation studies suggesting that syringe–needle rinsing by injectors may simultaneously serve to reduce viral burden and the chances of needle clogging and pointing out that water rinsing may be an effective HIV risk reduction step.²²

Syringes with fixed needles were less likely to become clogged by blood compared to the detachable LDS syringe attached to the same gauge needle. The use of needles that are more likely to become clogged by residual blood may encourage more frequent rinsing and/or disinfection, but it could also lead to more frequent sharing of available unclogged but used needles and inadvertently increase the injector's risk for HIV in places where sufficient access to sterile syringes is limited.^{23,24}

Studies have shown that the types and size of syringes used by drug injectors vary according to availability, local preferences, and cultural practices.^{25–27} Syringes with fixed needles may not always be useful to or acceptable among people who inject drugs. For this reason, needle exchange programs distribute the types of needles and syringes preferred by local drug users.²⁸ Our findings suggest that even when LDS syringe–needle designs are distributed, caution about their potential risk for HIV transmission relative to syringes with fixed needles must not be minimized. The results of this study support the need to emphasize the importance of rinsing and disinfecting syringes and needles when distributing all types of syringe–needle designs, including the LDS designs.

We tried to replicate as closely as possible the practices in actual use by injectors and simulating these practices in the laboratory introduces several limitations into our studies. We chose not to eliminate several factors that introduce variations in our laboratory assays.^{14,18,19} We used clinical isolates rather than laboratory strains of HIV, used HIV-infected blood containing cell-free and cell-associated virus rather than more purified cell free HIV, and used blood from different randomly chosen donors for the preparation of HIV-infected blood and cell cultures in each experiment. Thus, HIV titers in our study served as positive controls only and not for the quantification of viral reduction after syringe–needle rinsing and storage. Our findings are a representation of the performance of syringe–needle combinations relative to each other and not meant to be a measure of their viral reduction capability.

In our experiments, syringes were handled to simulate “booting.”^{15–17} It results in the final residual contents of the syringe being almost entirely blood and it represents the worst-case scenario for the risk of HIV transmission via a contaminated syringe. In real life, variations in each individual in each individual's injection habits and blood characteristics (such as the density and ability to coagulate) could differ from our conditions. Blood used in the experiments was collected using EDTA, a chemical anticoagulant. A number of factors that affect HIV viability inside syringes were not addressed in this study, including blood volume, whether the blood is more or less diluted by the presence of drugs in the syringes and other chemical substances used to adulterate or prepare drugs, and the titer of HIV in the blood.

This study did not investigate the ability of contaminated syringe–needle combinations to cause actual infections. Whether a person becomes infected with HIV depends on several factors that were not investigated in this study, such as the inoculum's volume and viral titer, the location of the puncture/injection, and the host's immunologic reactions.

To enable the comparison of the different experiment scenarios, this study used blood with relatively high titers of infectious HIV. Yet, in places where the use of antiretroviral therapy (ART) to reduce the risk for HIV transmission is widespread, the amount of HIV in the blood of people living with HIV, and thereby in the blood contaminating syringes, is likely to be lower.^{29,30} Successful ART can reduce the viral load in the blood to undetectable levels.³¹ This can range from <40 copies per ml to <400 in some studies.^{32,33} However, viral load is a measure of the average level of HIV RNA, which can derive from infectious and uninfected particles. It does not always correlate with the titer of infectious HIV, which more accurately represents the likelihood of whether an exposure to HIV will lead to infection. Many people who inject illicit drugs have poor health, little access to healthcare, and are more likely to miss medications and develop ART drug resistance. This makes them more likely to have higher amounts of HIV in the blood compared to people receiving ART who do not inject drugs.^{34–36} In addition, undetectable viral load does not mean that there is no virus but rather that the amount of HIV is below a level that tests can detect³³ and it is unknown how much treatment can reduce the risk of intravenous HIV transmission and what the intravenous transmission risk is when the HIV blood level is undetectable. Thus, the HIV blood titers in this study might be a reasonable representation of the real life intravenous exposure risk of underserved populations of drug injectors.

For these reasons, although insulin syringes were superior to the syringe and needle designs that were tested and rinsing syringes with water was better than not rinsing, it is with caution that we recommend the rinsing of syringes with water over no rinsing and the use of insulin syringes with permanently attached needles over the detachable syringe–needle combinations tested. We do not want to imply that sharing insulin syringes is safe or that syringes should be rinsed with water rather than bleach. Instead, we propose that needle exchange and other harm reduction programs and HIV education efforts emphasize a hierarchy of risk reduction starting with a clean, sterile syringe for every injection, then reuse of one's own syringe, and only as a last resort using someone else's syringe but only after bleach disinfection or multiple rinses with clean water.

Finally, the improvements with the LDS designs tested in this study may seem unimpressive and the reduction in HIV recovery compared to the standard designs seems trivial. Nevertheless, small changes may make a difference. The manufacturers of LDS syringes and needles must continue their engineering efforts to design better “LDS” combinations with greater gusto.

In conclusion, despite the limitations in this study, there is room for cautious optimism with regard to the positive impact of using LDS syringe–needle combinations. However, such encouragement must be accompanied by the following information.

- Syringe designs with detachable needles were worse than the fixed needle design regardless of LDS configuration.
- Detachable LDS needles are superior to standard needles when needle gauge is small, that is, when the needle diameter is larger.
- Rinsing syringes with water markedly reduced the burden of infectious HIV from syringes compared to the storage of syringes.
- Distribution of LDS needles and syringes must be accompanied by public health efforts to improve syringe–needle rinsing and disinfection to reduce the risk of HIV transmission among people who inject drugs.
- People who inject drugs who reuse syringes must be made aware that they are at increased risk for HIV transmission even when reusing syringes with fixed needles or LDS designs and even when rinsing syringes with water.

We recommend that all injections, including those made by people who inject drugs, use a new sterile syringe. We cannot overstate the importance of increased access to sterile syringes through pharmacy sale, syringe exchange programs, and physicians, as well as the removal of legal penalties and police harassment for possession of syringes.^{37,38}

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