

Blood-Borne Viral Pathogens Live On: Implications for Biosafety & Infection Control

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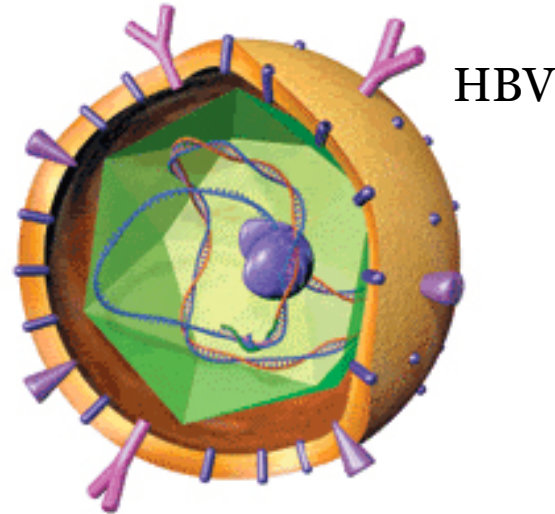
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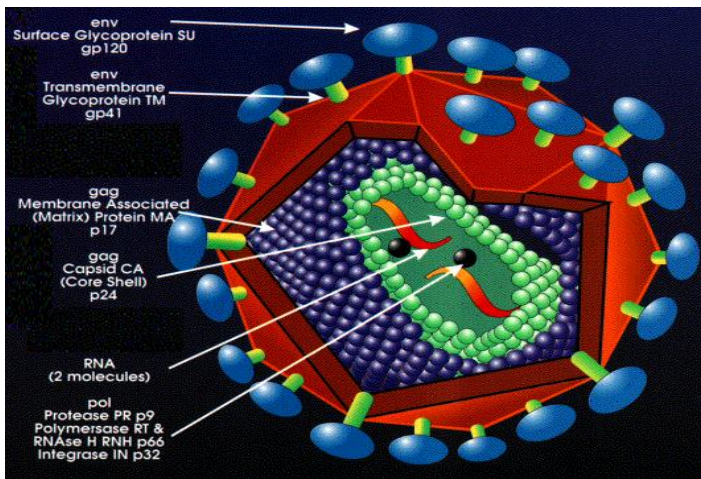
Outline

- Global burden of the BIG 3
- Routes of transmissions and why we care about the BIG 3
- HBV survival
- HIV survival
- HCV survival

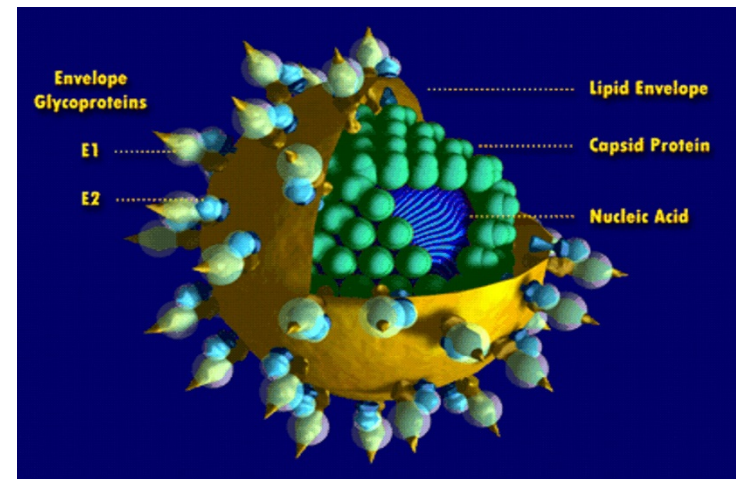
“The BIG 3”



HIV



HCV



Global Burden of the BIG 3

HBV:

- 400 million HBV carriers in the world
- 1 million people die annually from HBV-related liver disease

HIV:

- 35 million people living with HIV
- 1.5 million HIV/AIDS related deaths annually

HCV:

- 170 million people are infected worldwide with hepatitis C virus
- 70 to 80% develop chronic HCV infections
- Cost of liver transplantation

Routes of Transmission



HIV and HCV among IDUs

- Injection drug use is second most common risk factor for HIV.
- In the U. S., 1 in 7 IDUs is HIV seropositive.
- Prevention programs can reduce HIV transmission.
- Injection drug use is most common risk factor for HCV.
- In the U. S., 3 in 4 IDUs are HCV seropositive.
- Prevention programs do not seem to reduce HCV transmission.



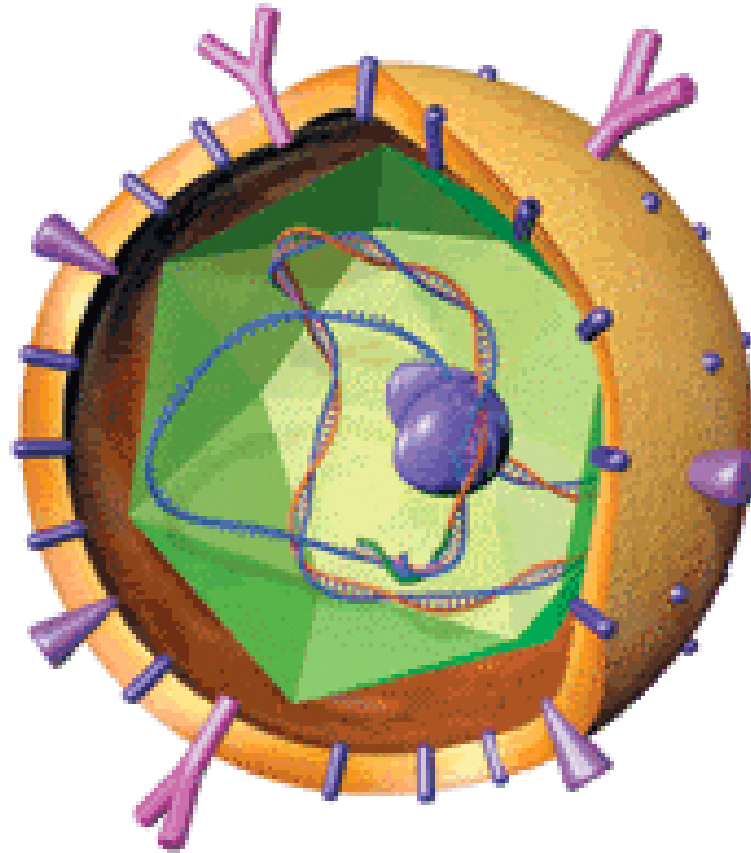
Healthcare Transmission

– HBV, HIV & HCV

- **Accidental needle stick injury**: HCV transmission occurs approximately 10X more frequently than HIV: (HIV 0.3% and HCV 3%).
Short & Bell 1993 *Amer. J. Infect. Control* 21:343-350
- In an Italian study of 214 patients with acute HCV the most relevant associated risk factors were: Santantonio et al. *CID* 2006;43:1154-1159

history of medical procedures (32%) (e.g., hospitalization, surgery, endoscopy, dialysis, blood transfusion, dental treatment, or other invasive procedures),
intravenous drug use (30%),
unknown (13%); sexual contact (10%); household contact (7%); accidental exposures (5%), and tattoos and/or body piercing (3%)

HBV



Environmental Surfaces positive for HBsAg in a dialysis area

Environmental surface, sample no.	Cpm of sample	Cpm of cutoff value*
Negative controls (<i>n</i> = 6)†	209 (174-239)	
Positive controls (<i>n</i> = 6)†	12,883 (6,683-19,669)	
Outer surface of blood collection containers (<i>n</i> = 11)		
1 (visible blood)	4,854	250
2 (visible blood)	6,807	250
3 (visible blood)	492	351
4 (no visible blood)	2,717	351
5 (no visible blood)	681	266
6 (no visible blood)	361	266
Specimen rack	386	266
Adjustment knob of sigmamotor pump	328	266
Blood-pressure monitor bulb	918	266

Lauer et al. JID 1979

Environmental Surfaces positive for HBsAg in a Clinical laboratory areas

Environmental surface, sample no.	Cpm of sample	Cpm of cutoff value*
Negative controls (<i>n</i> = 6) [†]	209 (174–239)	
Positive controls (<i>n</i> = 6) [†]	12,883 (6,683–19,669)	
Outer surface of serum specimen cup or vial (<i>n</i> = 9)		
1	432	351
2	2,507	351
3	15,383	351
4	5,629	266
Gloves and bare hands of medical technologist (<i>n</i> = 3)		
1, glove (visible blood)	2,846	367
2, bare hand (visible blood)	3,734	266
Pipetting aids, hand portion (<i>n</i> = 3)		
1	13,234	351
2	5,519	250
Marking devices (<i>n</i> = 10)		
1, ballpoint pen	628	266
2, felt marker	706	250
Container of NaCl solution (<i>n</i> = 1)	1,724	351
Coulter Counter (<i>n</i> = 6)		
1, adjacent counter surface	290	266
2, stem	1,636	266
3, gauze (visible blood)	359	266
4, surface around port where blood mixture is injected	1,492	266
Counter surface (where platelet determination is done)	466	266
Cover slip used to spread blood	5,955	367

Lauer et al. JID 1979

Transmission of HBV in Clinical Laboratory Areas

- The contamination rate for environmental surfaces was 15%.
- Transmission of HBV in the clinical laboratory could occur via hand contact with contaminated items during the various steps of blood processing
- Portal of entry of HBV is through inapparent breaks in skin and mucous membranes

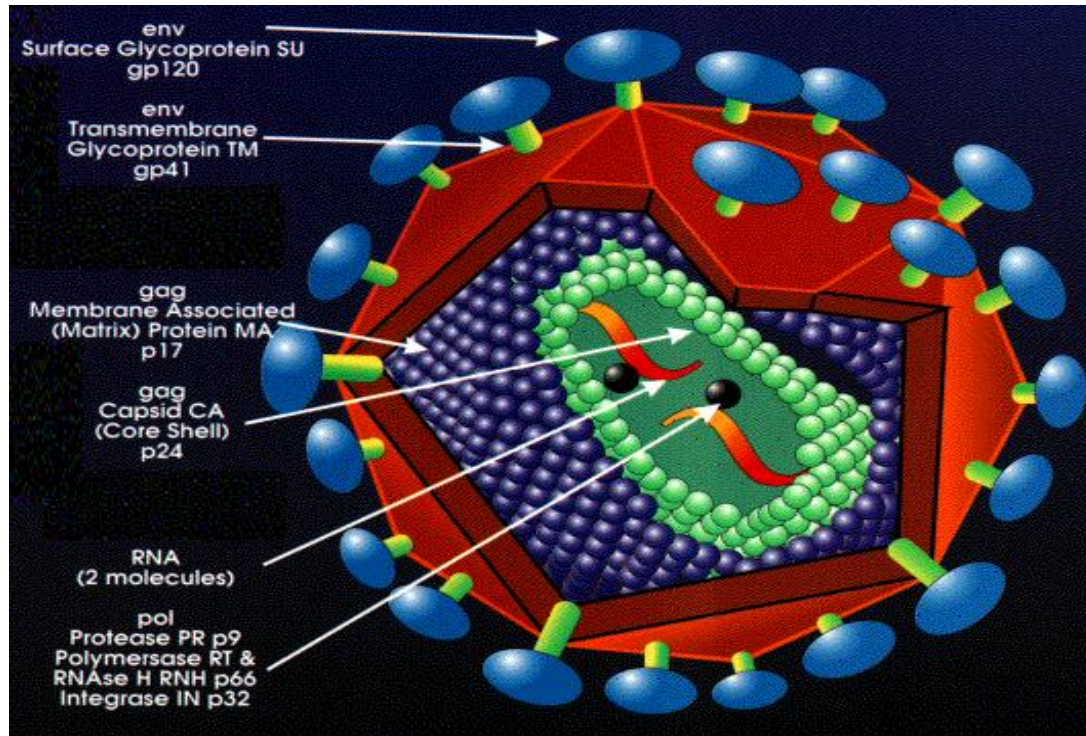
Survival of HBV at room temperature

- **Up to 7 days – Bond et al. Lancet 1981**
- Dried HBV contaminated plasma exposed to 70% isopropyl alcohol or 2% glutaraldehyde at pH 8.6 was not infectious in chimpanzees – Bond et al. J Clin Microbiol 1983

Inactivation of HBV with the chimpanzee model

Germicide tested	Test conditions	Degree of virus inactivation
0.7% (w/v) Formaldehyde	1 Hr at 20°C (68°F)	99.9%
Bleach (500 ppm free chlorine)	10 Min at 20°C (68°F)	Complete inactivation
2% (w/v) Glutaraldehyde	10 Min at 20°C (68°F)	Complete inactivation
70% Isopropanol	10 Min at 20°C (68°F)	Complete inactivation
1% Glutaraldehyde	5 Min at 24°C (75.2°F)	Complete inactivation
0.1% Glutaraldehyde	5 Min at 24°C (75.2°F)	Complete inactivation
80% (v/v) Ethanol	2 Min at 11°C (51.8°F)	Complete inactivation
Quaternary ammoniums (500 and 703 ppm)	10 Min at 20°C (68°F)	Complete inactivation
Phenolic (702 ppm)	10 Min at 20°C (68°F)	Complete inactivation

HIV

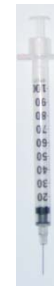
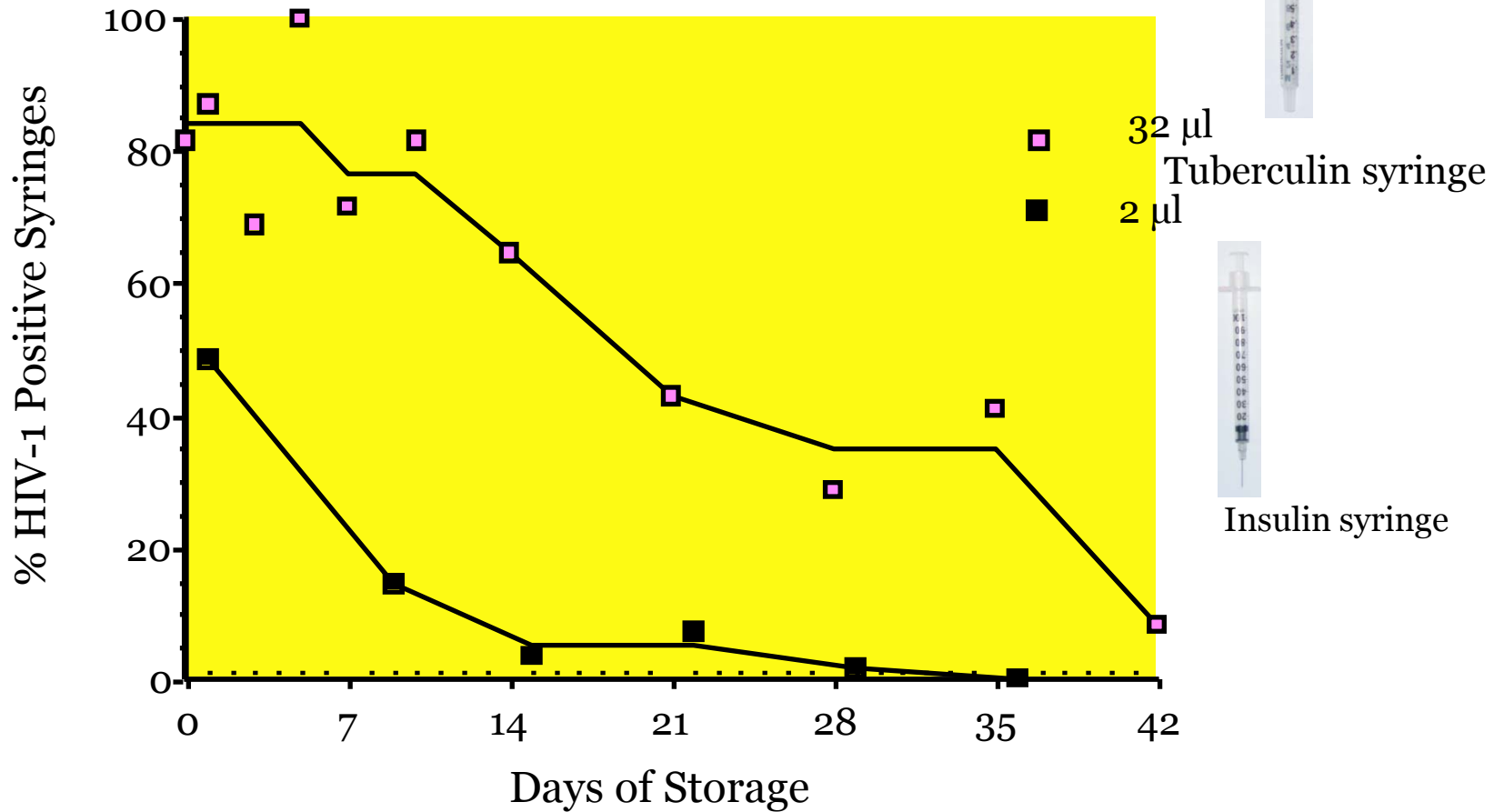


Survival of HIV at Room Temperature

- HIV dries in room temperature in about 3 hours¹
- Retains infectivity for up to 7 days²

1. Van Bueren J et al. 1994 J Clin Microbiol
2. Barre-Sinoussi F et al. 1995 Lancet

Survival of HIV in Syringes



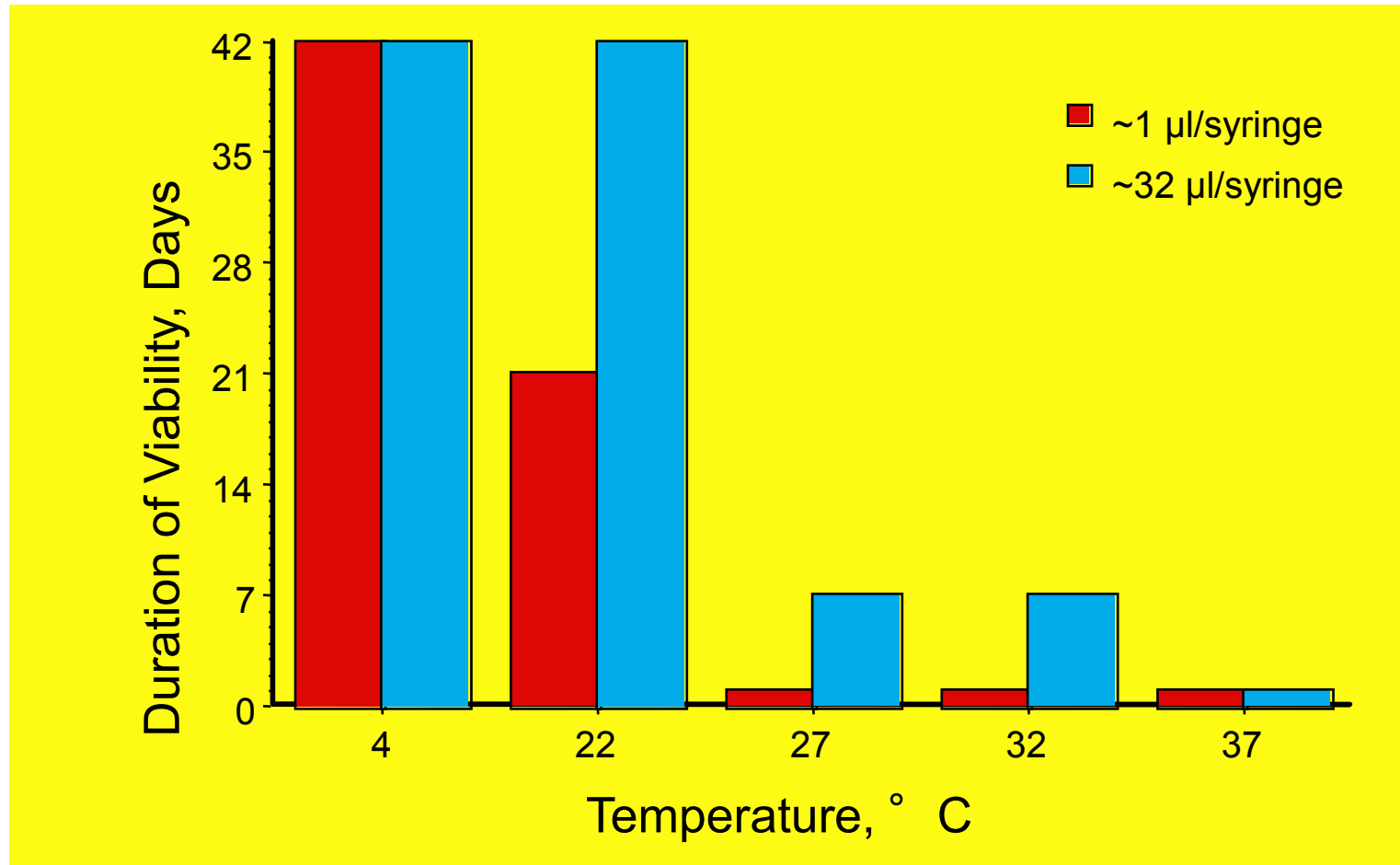
32 µl
Tuberculin syringe

2 µl

Insulin syringe

Heimer et al

Temperature of storage affects survival of HIV in syringes



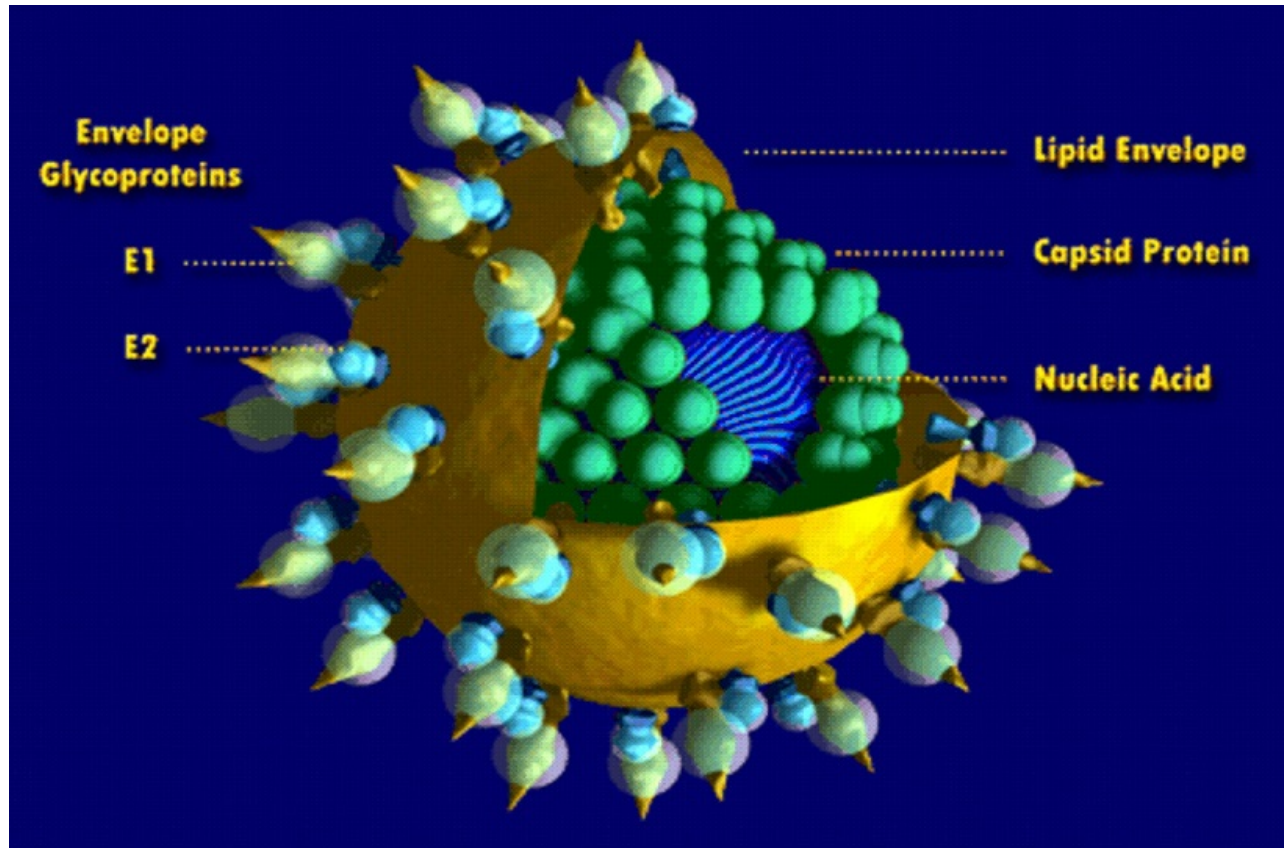
Heimer et al

Recovery HIV from syringes rinsed with bleach

Condition	Recovery of HIV (%)
No rinse	146 of 146 (100)
1 x (H ₂ O)	42 of 128 (33)
1 x diluted bleach	27 of 80 (34)
1 x undiluted bleach	1 of 153 (0.7)
2 x (H ₂ O)	17 of 160 (11)
2 x (H ₂ O + dil. Bleach)	1 of 50 (2)
2 x (dil. Bleach + H ₂ O)	2 of 50 (4)

Abdala et al JAIDS 2001

HCV



Physical Comparison of HIV AND HCV

- Both HIV and HCV are RNA viruses containing single stranded RNA
- HIV viral genome is similar in length to HCV viral genome
- RNA is surrounded by a protein capsid
- Enveloped in a membrane containing proteins encoded by the virus and lipids derived from the infected cell

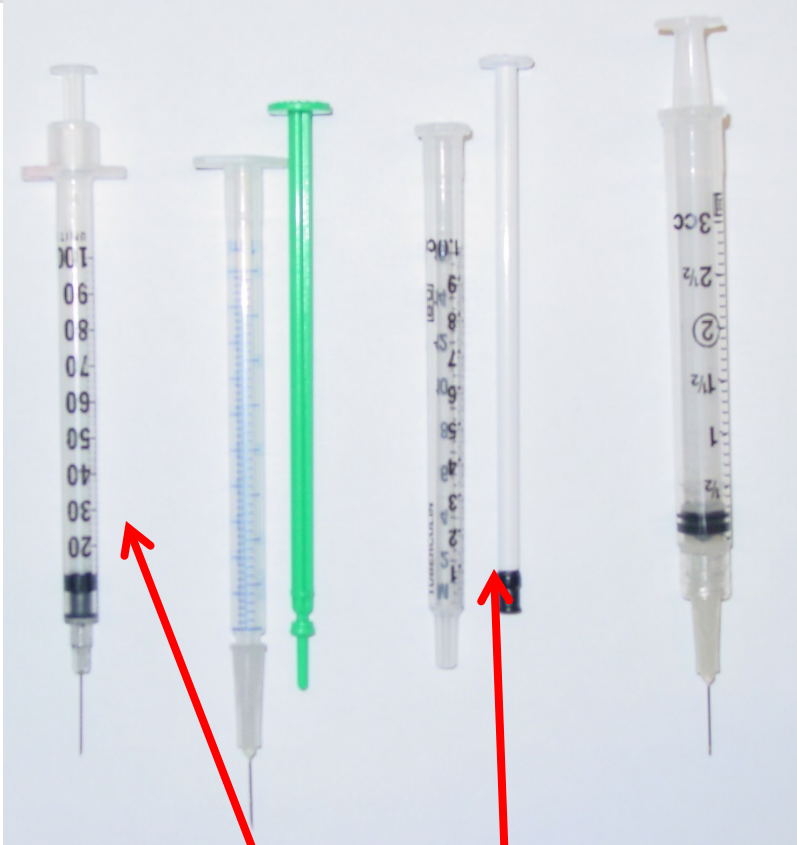
Why is HCV so much harder to control?



We hypothesized that the high prevalence of HCV among IDUs may be due to the ability of the virus to remain viable in contaminated syringes for prolonged periods



Syringe Type



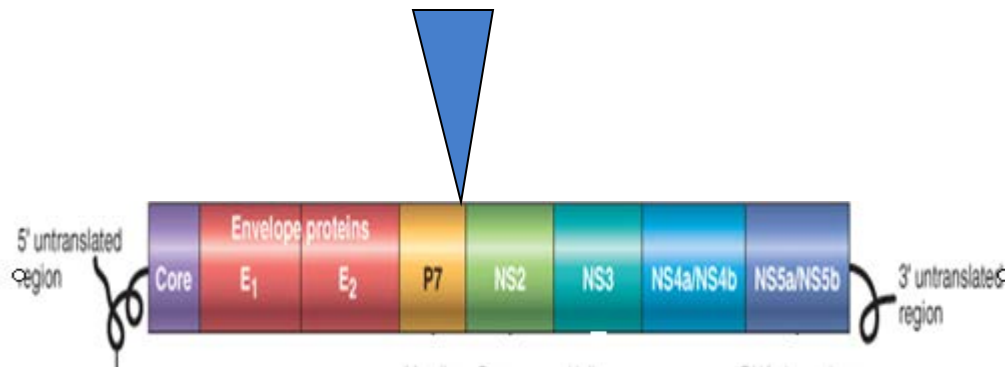
~2 μ l void volume

~32 μ l void volume



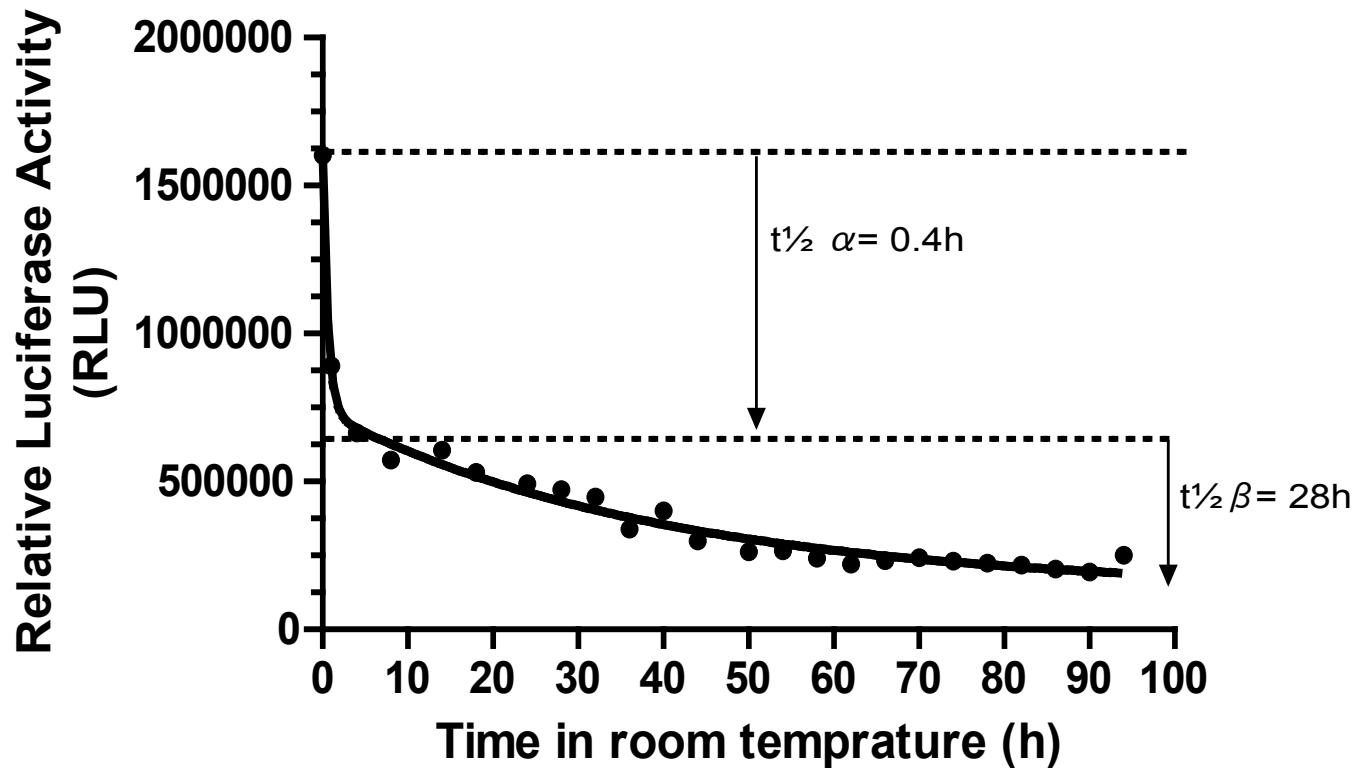
HCV Reporter Virus

- Jc1/GLuc2A is a genotype 2a virus with a luciferase gene from *Gaussia princeps* inserted between the p7 and NS2 genes



- Viral stocks of Jc1/GLuc2A reporter virus were prepared by RNA transfection of Huh-7.5 cells.

Bi-phasic Decay of HCV at room temperature

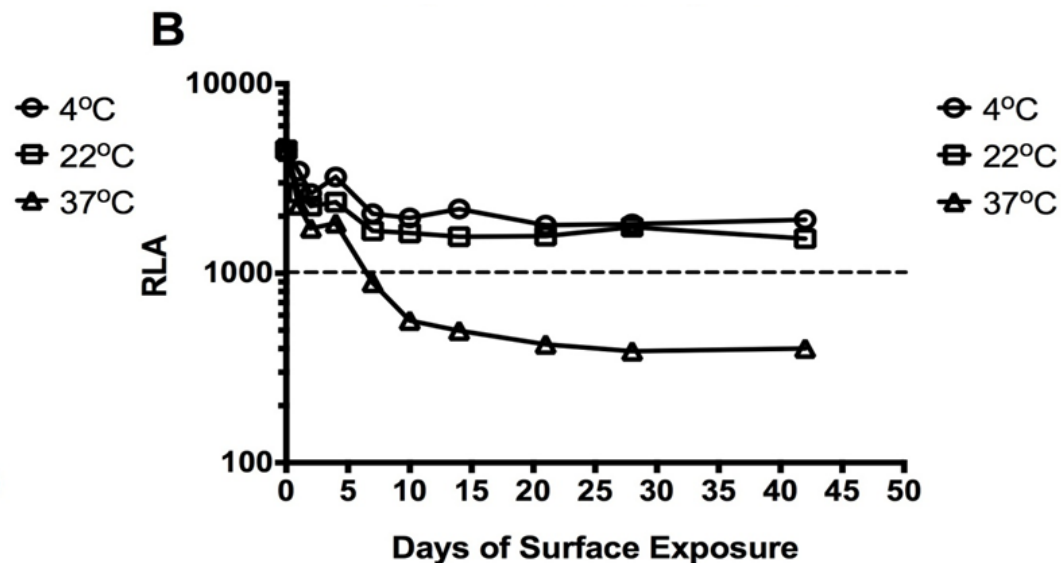
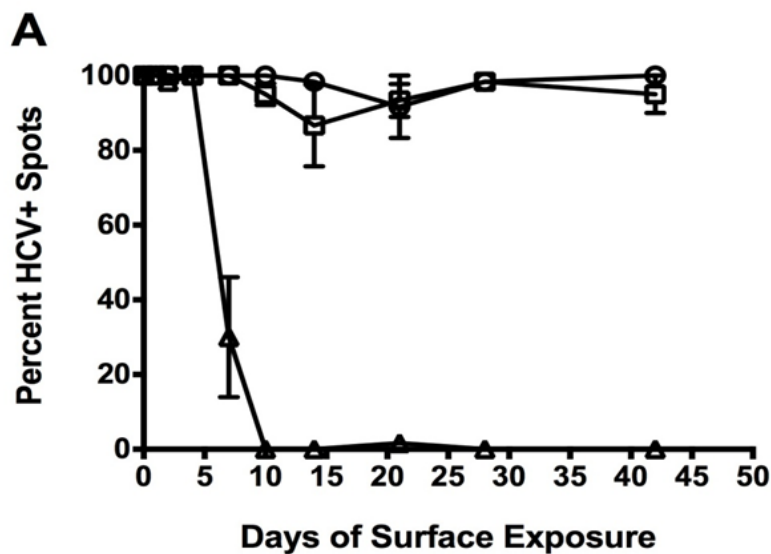


Time to Dryness of HCV drops on surfaces

- 4, 24 , and 28 hrs at 22 (benchttop), 4 (refrigerator), and 37° (incubator), respectively
- Humidity at storage condition: 4, 22, 37° was 53%, 44% and 82%, respectively
- Time to dryness correlated positively with the humidity

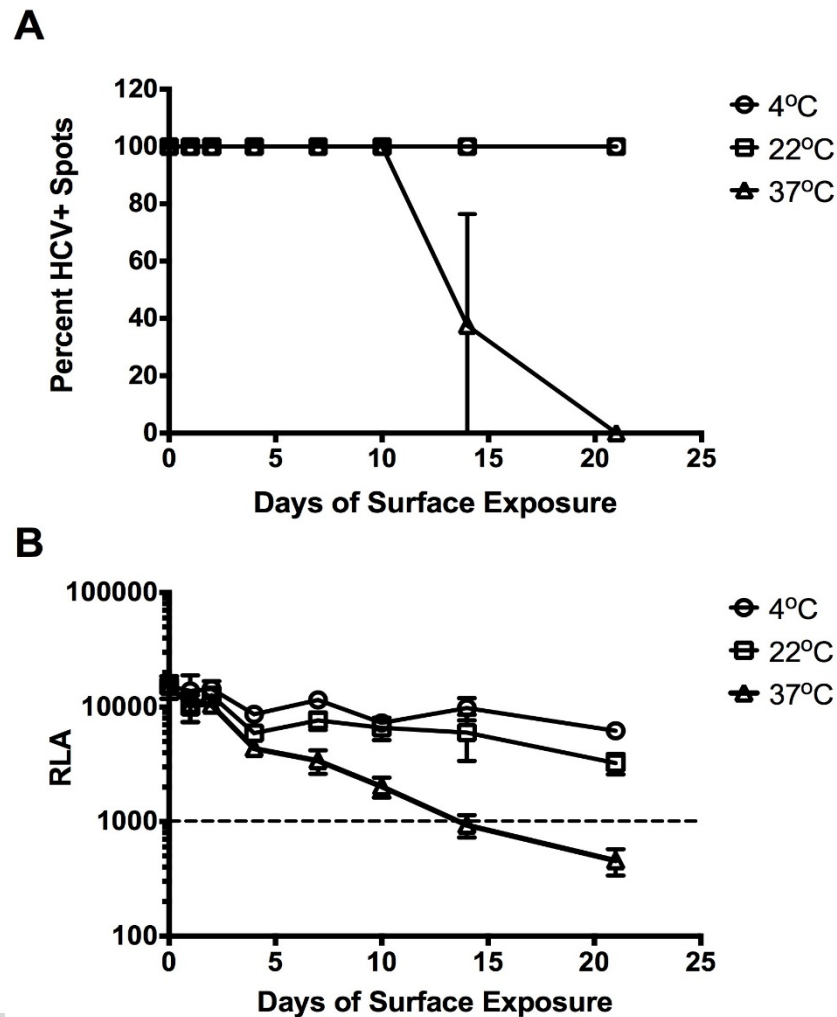
Paintsil et al. 2014. JID

Hepatitis C Virus Survives for Weeks after Drying on Inanimate Surfaces at Room Temperature



Paintsil et al. J Infect Dis. 2014 Apr 15;209(8):1205-11.

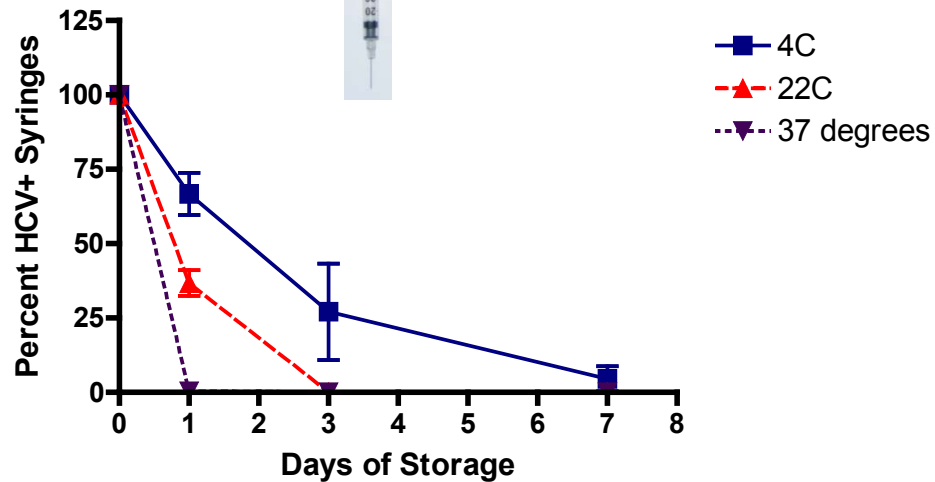
Survival of high-titer HCV after drying on surfaces



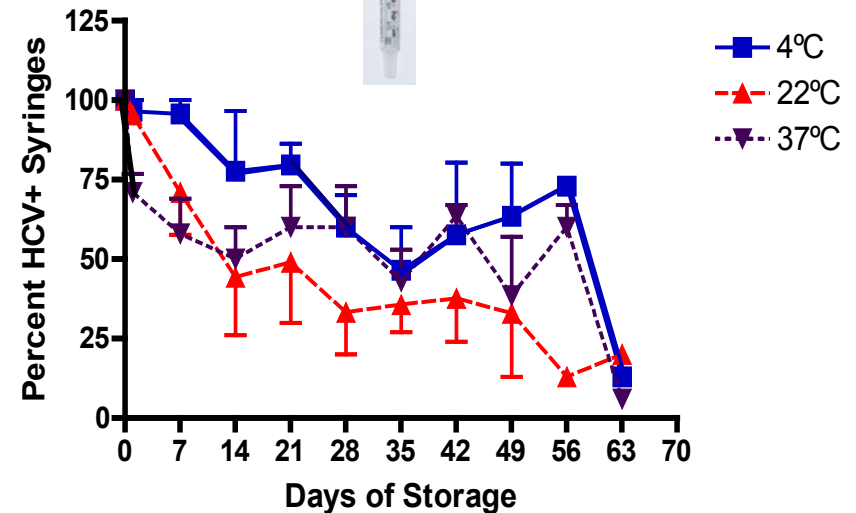
Paintsil et al. 2014. JID

HCV remain viable in high volume syringes for up to 63 days

Insulin syringe

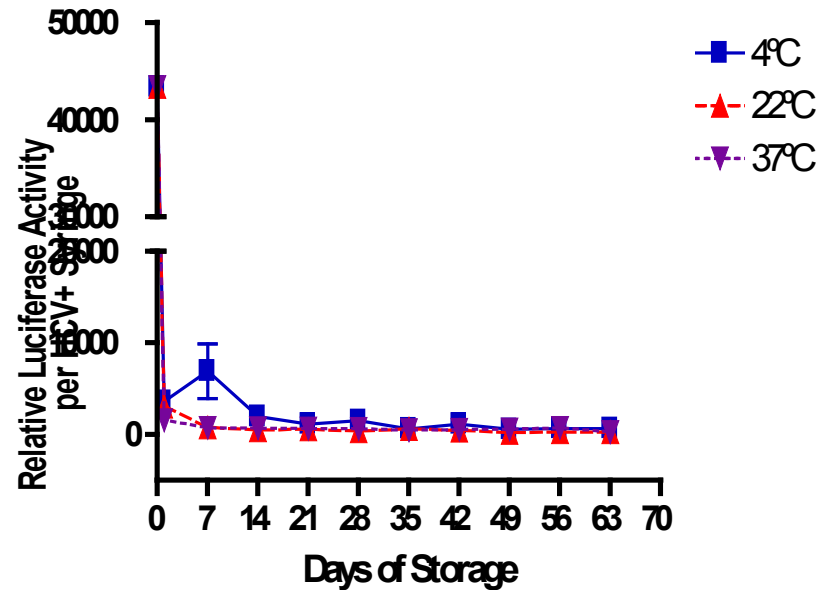
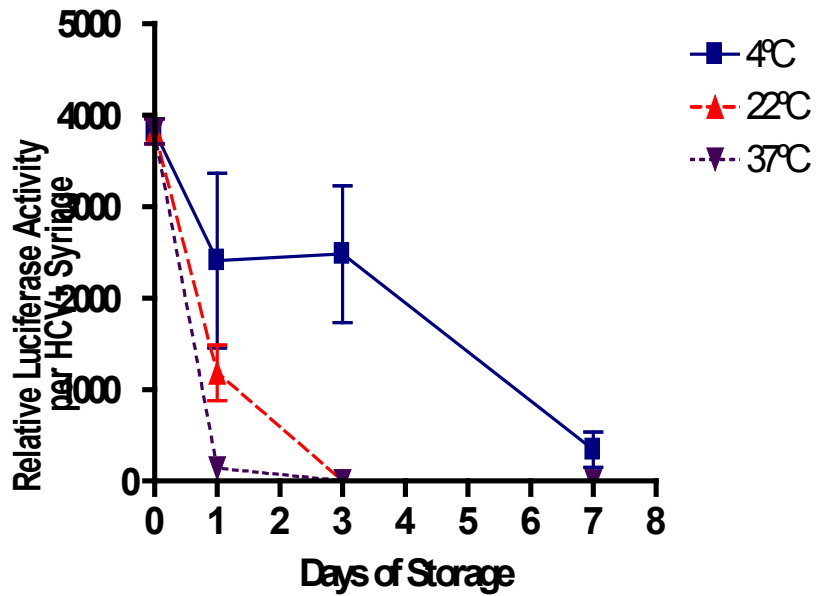


Tuberculin syringe

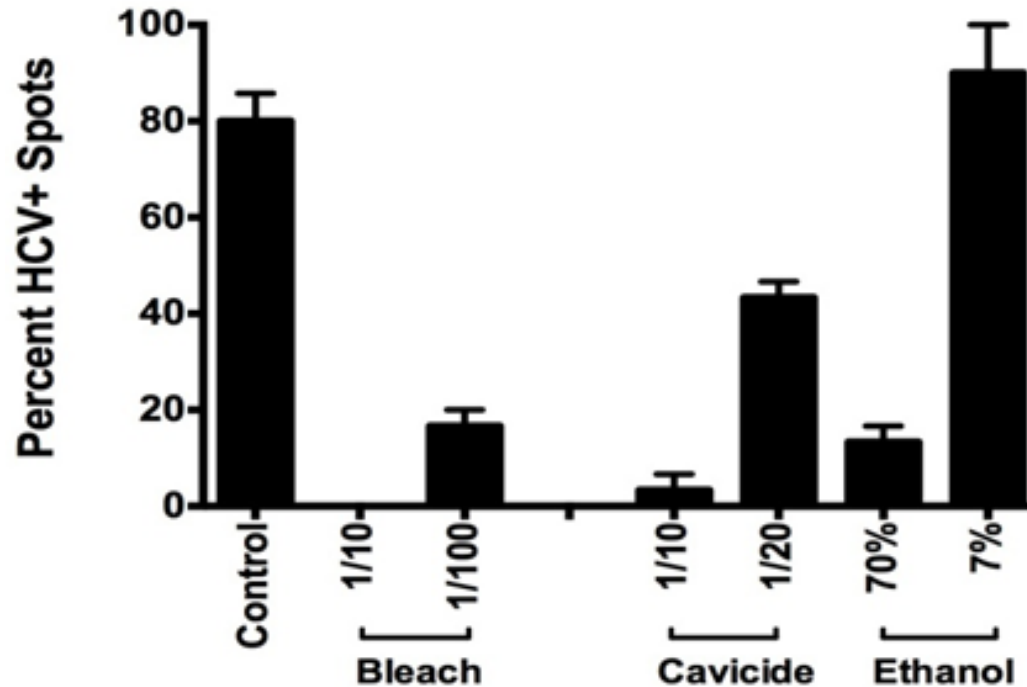


Paintsil et al. J Infect Dis. 1 2010;202(7):984-990

Infectivity of HCV in syringes after storage

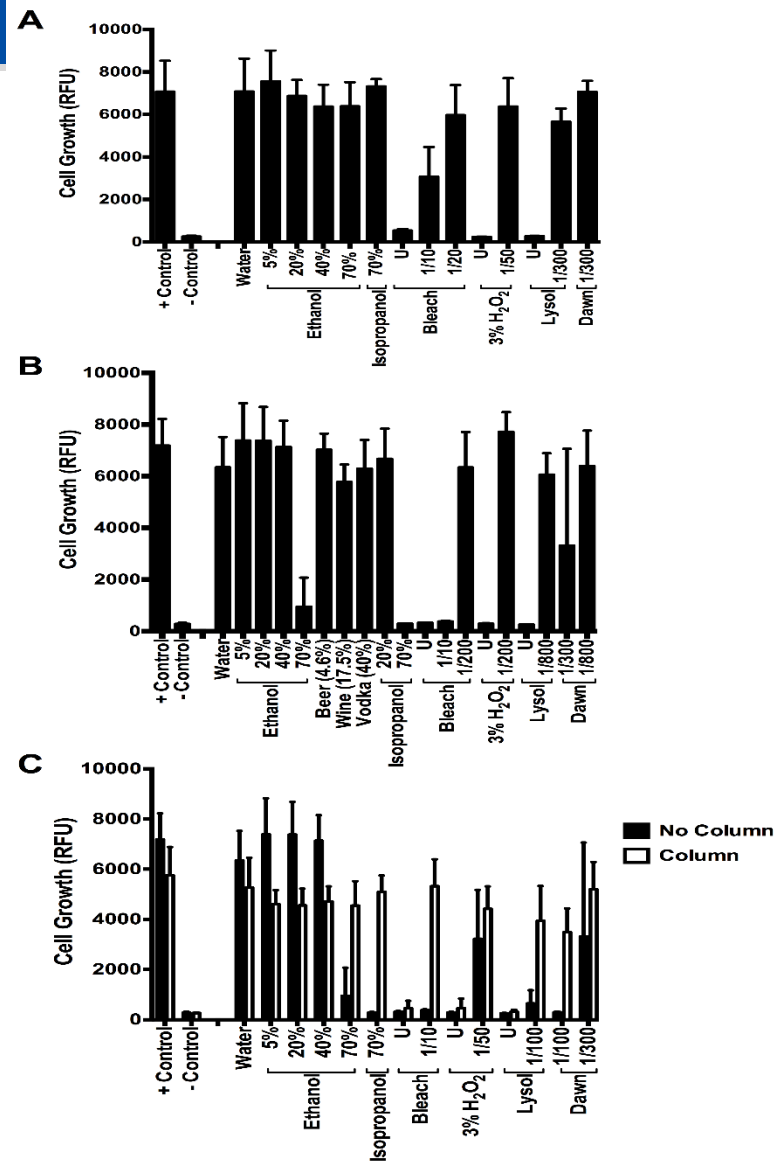


Effectiveness of Antiseptics on HCV Contaminated Surfaces



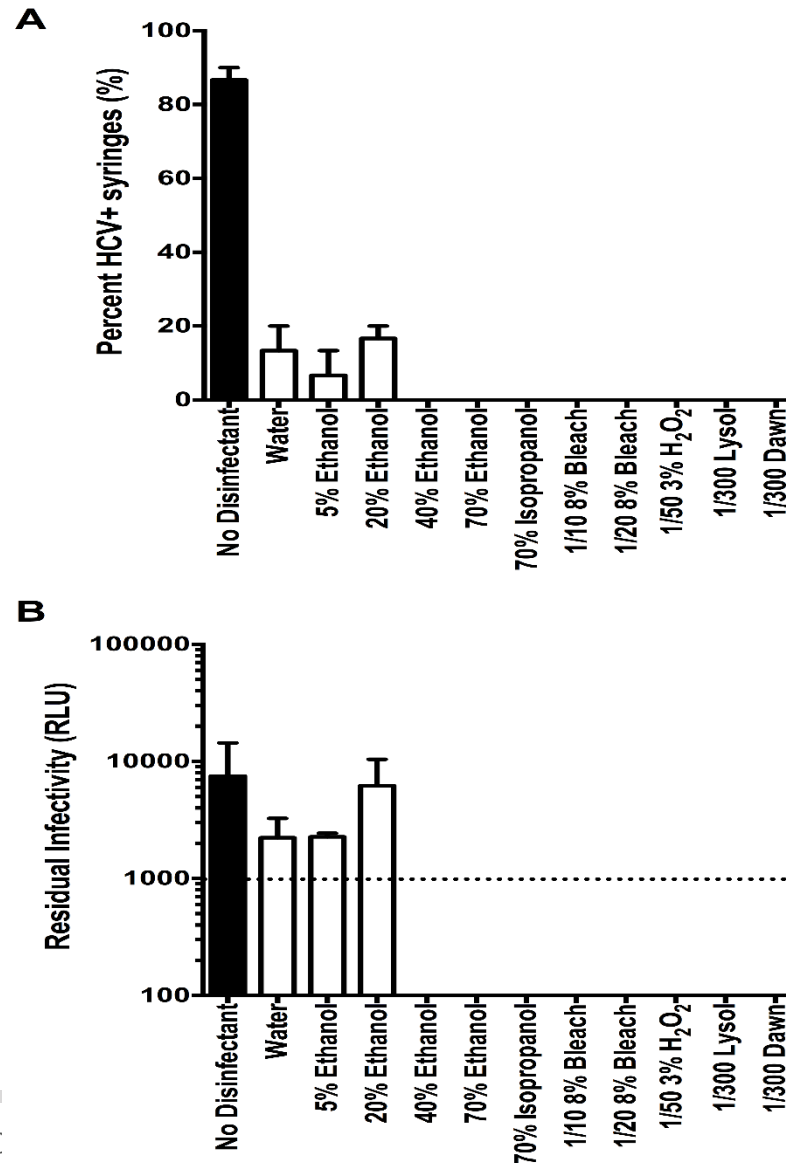
Paintsil et al. J Infect Dis. 2014 Apr 15;209(8):1205-11.

Effect of household products on cell growth (Huh-7.5 cells)



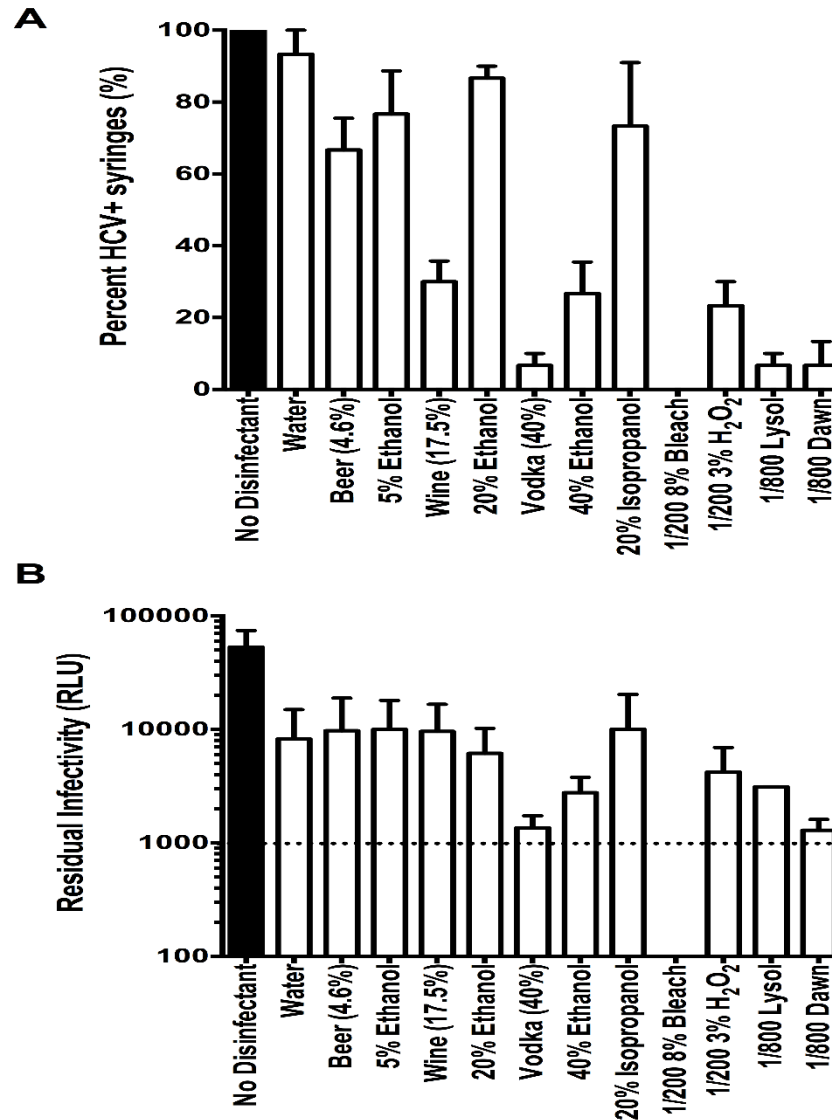
Binka et al. 2015. OFID

Survival of HCV in Insulin Syringes after rinsing once with household products

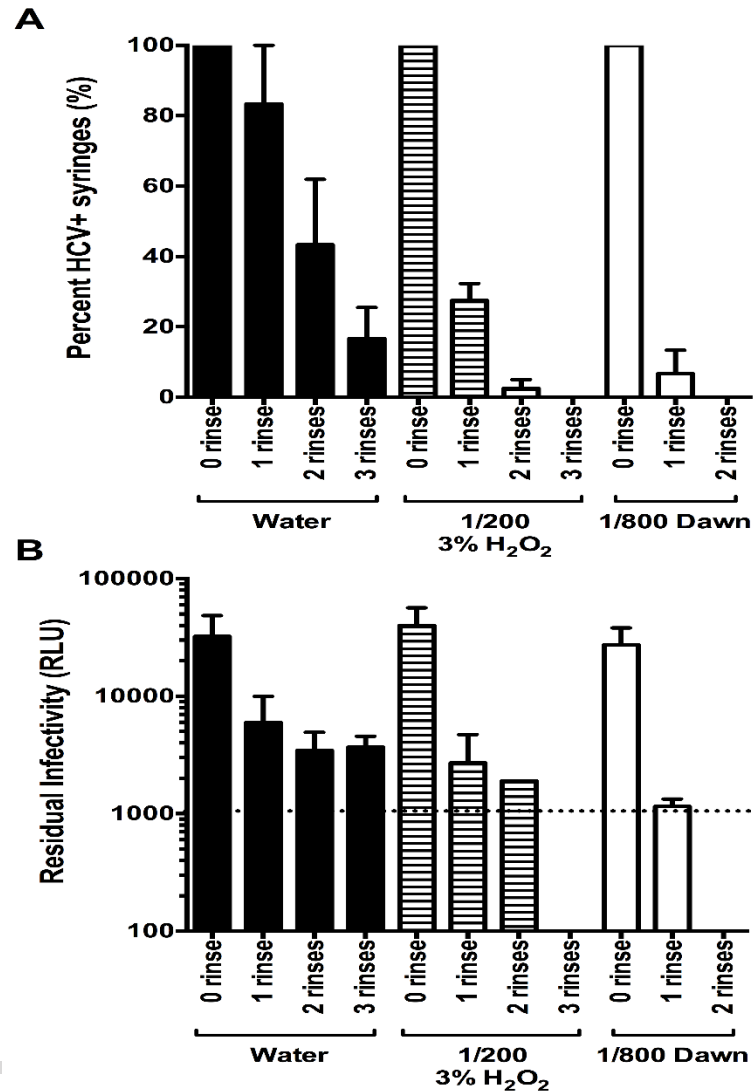


Binka et al. 2015. OFID

Survival of HCV in Tuberculin Syringes after rinsing once with household products



Survival of HCV in Tuberculin Syringes after multiple rinses with household products



Summary

- Survival is dependent on syringe type – syringes with detachable needles appear far more likely to transmit HIV and HCV
- Lower temperatures preserve HCV viability in low void volume syringes more than in high void volume ones
- HCV and HIV survival in low void volume syringes show similar time course, but HCV appears to survive longer than HIV in high void volume syringes
- Anti-HCV activity of commercial/household antiseptics varies

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