University of BRISTOL

The contribution of unstable housing to HIV and hepatitis C virus transmission among people who inject drugs globally, regionally, and at country level: a modelling study

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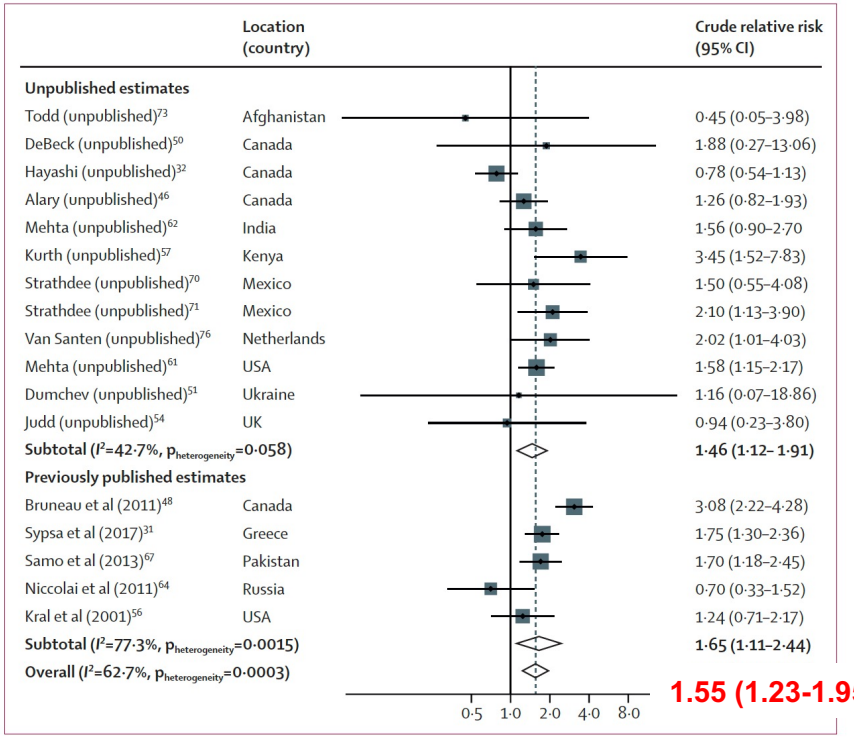
Unstable Housing and PWID

- Growing recognition of the role of social and structural factors (“risk environment”) in influencing risk behaviours and the need to expand current prevention efforts to address them.
- Unstable housing, defined as lacking access to fixed housing
  - includes homelessness (extreme end of the spectrum)
- Globally, 22% of PWID have recently experienced unstable housing or homelessness (currently or within the past year)[1]
  - In some regions like North America, this proportion reaches 50% [1]
- Homelessness has been linked to recent outbreaks of HIV infection in several European cities, Israel and Canada, despite the availability of comprehensive harm reduction in some of these settings [2]

1. Degenhardt et al. *Lancet Glob Health* 2017
2. Des Jarlais et al. Lancet HIV 2020

Unstable Housing Increases Risk of HIV Acquisition among PWID



- 17 crude estimates; 12 of which unpublished
- Unstable housing/homelessness associated with 55% increase in risk of HIV acquisition
- Effect persisted when pooling adjusted estimates but was lower than crude estimates: 1.39 vs 1.55
- No difference in effect by region.

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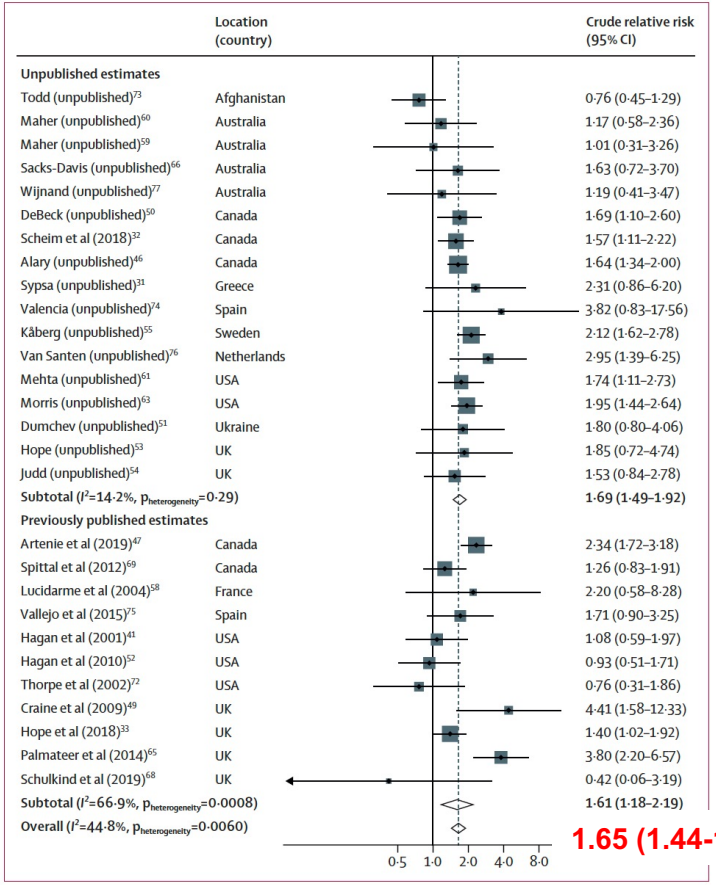
Arum et al. Lancet Public Health 2021;
Stone INHSU 2021 on demand Abstract 116

Unstable Housing Increases Risk of HCV Acquisition among PWID



- 28 crude estimates; 17 of which unpublished
- Unstable housing/homelessness associated with 65% increase in risk of HCV acquisition
- Effect persisted when pooling adjusted estimates and pooled effect was similar: 1.64 vs 1.65
- Estimates higher in Europe (2.06) than other regions.

Arum et al. Lancet Public Health 2021;
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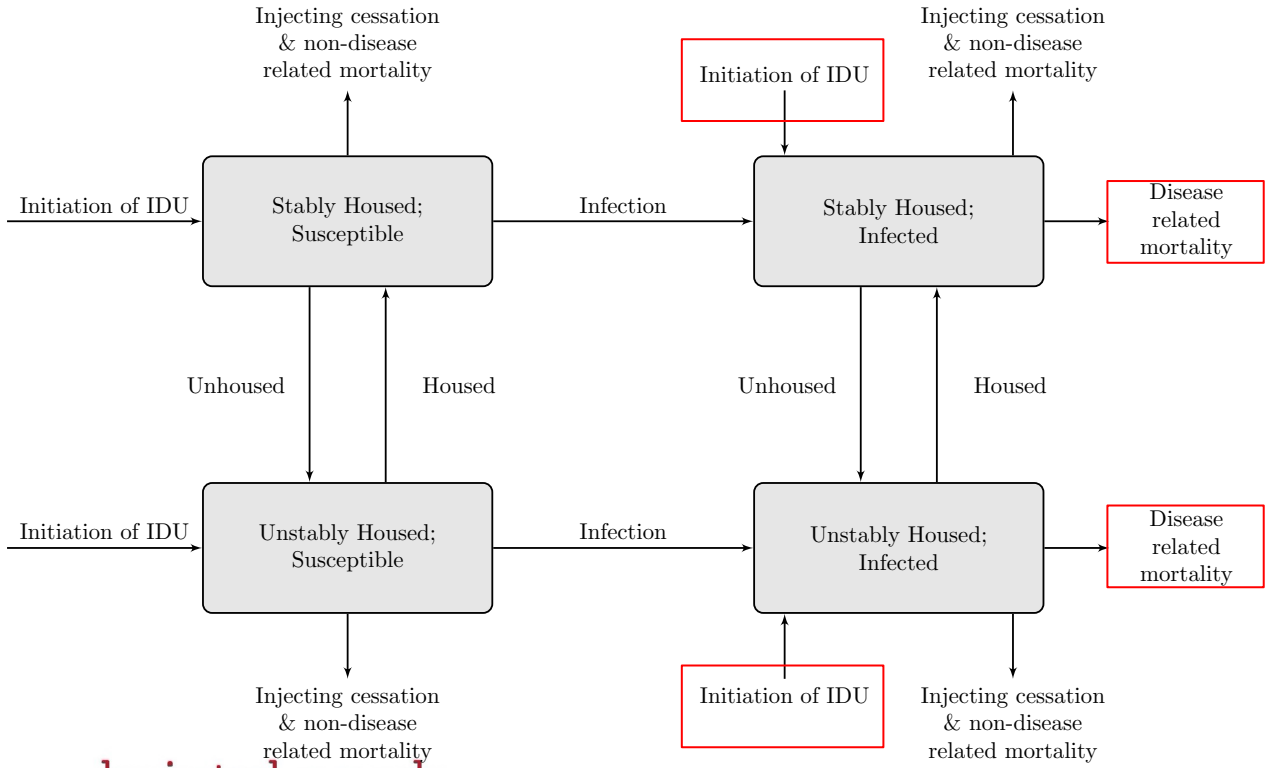
AIM

- Estimate the contribution of unstable housing to HIV and HCV transmission among PWID
  - Nationally
  - Regionally
  - Globally

- Main estimates: transmission population attributable fraction (tPAF) using mathematical model
- Compare these estimates with classical population attributable fraction (cPAF)

Model Description



- Assumes random mixing
- An indirect effect of HIV treatment was included by adjusting the rate of HIV-related mortality to reflect the proportion of HIV-infected PWID who are on ART.
- All individuals assumed to start injecting HIV/HCV negative
  - Except in Sub-Saharan Africa, where we assume HIV prevalence at initiation is same as 15-24 year-olds in general public (data from UNAIDS)
- Assume % individuals starting injecting as unstably housed is same as % of PWID unstably housed (Varied in sensitivity analyses).

Key Model Parameters

HIV prevalence	Differs by country	National estimates from Degenhardt et al. Lancet Glob Health 2017 or Mumtaz et al. PLoS Med 2014.
Antibody HCV prevalence	Differs by country	National estimates from Degenhardt et al. Lancet Glob Health 2017
PWID population size	Differs by country	National estimates from Degenhardt et al. Lancet Glob Health 2017 or Mumtaz et al. PLoS Med 2014.
Proportion of PWID that are unstably housed	Differs by country	National estimates from Degenhardt et al. Lancet Glob Health 2017 or Arum et al. Lancet Pub Health 2021
Average duration of injecting	Differs by country/region*	National/Regional estimates Hines et al. Lancet Glob Health 2020
Relative increase in HIV transmission risk if unstably housed	1.39 (95%CI: 1.06-1.84)	aRR from Arum et al. Lancet Pub Health 2021
Relative increase in HCV transmission risk if unstably housed	1.64 (95%CI: 1.43-1.89)	aRR from Arum et al. Lancet Pub Health 2021
Average duration of unstable housing (years)	0.25-2	Range across estimates from Scotland, Canada, USA and Australia

*Regional values used if national estimates were missing because initial model analyses showed that average duration of injecting had little impact on tPAF.

- Degenhardt 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
- Hines et al. Associations between national development indicators and the age profile of people who inject drugs: results from a global systematic review and meta-analysis. *Lancet Glob Health* 2020
- Mumtaz et al. HIV among people who inject drugs in the Middle East and North Africa: systematic review and data synthesis. *PLoS Med* 2014; **11**(6): e1001663.
- Arum C et al. Homelessness, unstable housing and risk of HIV and hepatitis C virus acquisition among people who inject drugs - a systematic review and meta-analysis. *Lancet Public Health 2021*

Model Calibration

- For each country, 1,000 parameter sets were sampled from their distributions
- The model was then separately calibrated for HIV and/or HCV using nonlinear least-squares fitting.
  - **Assuming both prevalence of HIV/HCV and unstable housing are stable**

Model Analyses: Transmission PAF (tPAF)

- Unlike classical PAFs, tPAFs account for the onward chain of transmission resulting from an infection event [1]
- The baseline model fits for each country were run for a 10-year period
- Run counterfactual scenario where the increased risk of HIV or HCV transmission was removed (RR set to 1) in each model fit over that same 10-year period.
- $National\ tPAF = 100 - 100 * \frac{New\ infections\ in\ counterfactual\ scenario\ over\ 10\ years}{New\ infections\ in\ baseline\ scenario\ over\ 10\ years}$
- $Regional\ tPAF = 100 - 100 * \frac{\sum_{countries} New\ infections\ in\ counterfactual\ scenario\ over\ 10\ years}{\sum_{countries} New\ infections\ in\ baseline\ scenario\ over\ 10\ years}$

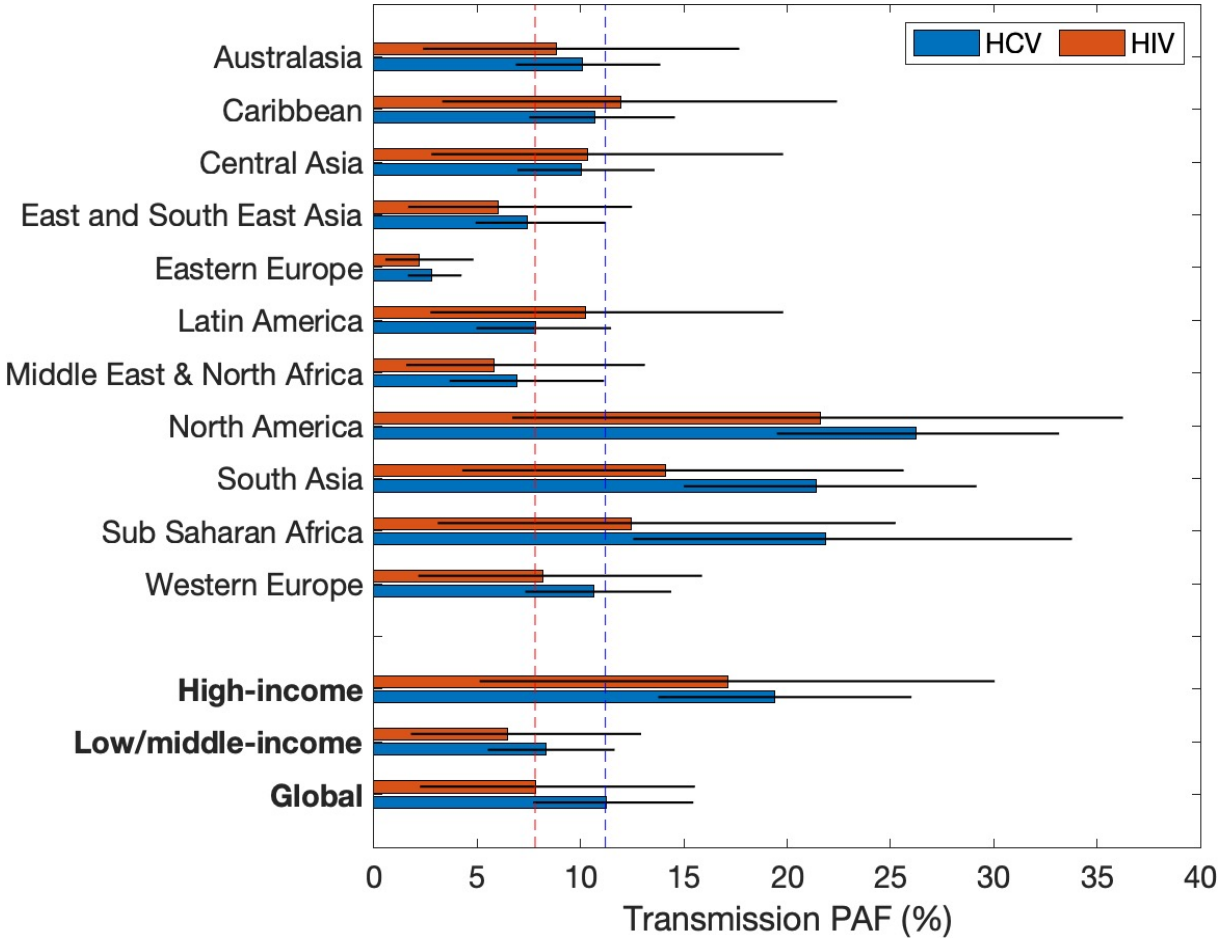
1. Mishra et al. Lancet Infect Dis 2020

Results

- The model projected HIV and HCV tPAF estimates for 56 and 55 countries with *sufficient data*, accounting for 10.6 million PWID, approximately two-thirds of the world's PWID population.

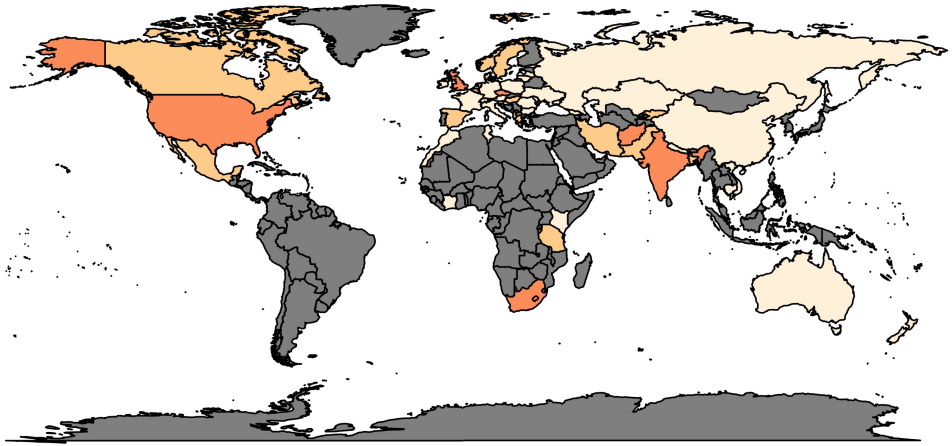
- Across all countries with *sufficient data* and population size estimates:
  - tPAF for HIV: 7.8% (95% CrI: 2.2−15.5%) – 50 countries
  - tPAF for HCV: 11.2% (95%CrI: 7.7−15.5%) – 49 countries

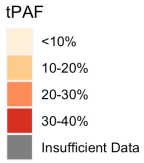
Results



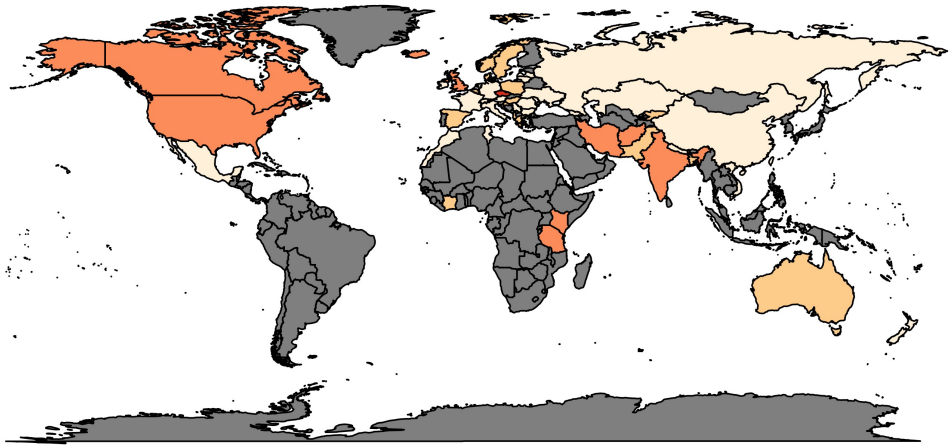
- tPAFs for HIV ranged from 2.2% in Eastern Europe to 21.6% in North America.
- tPAFs for HCV ranged from 2.8% in Eastern Europe to 26.2% in North America.
- The median tPAFs for HCV were also above 20% in Sub Saharan Africa and South Asia.
- For both HIV and HCV, the tPAFs in high income countries (HIV: 17.2%; HCV: 19.4%) were over double those in low/middle income countries (HIV: 8.3%; HCV: 6.5%).
- However, tPAFs are largely dominated by countries with large PWID populations: the US and China and Russia, respectively.

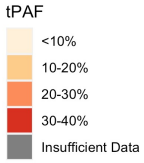
HIV





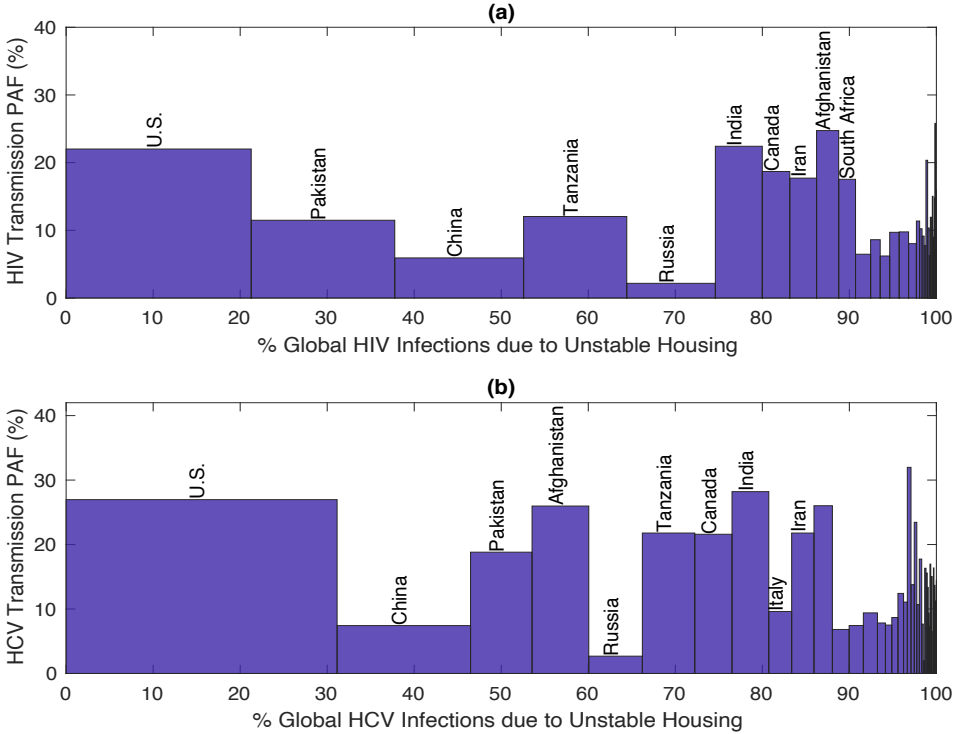
HCV





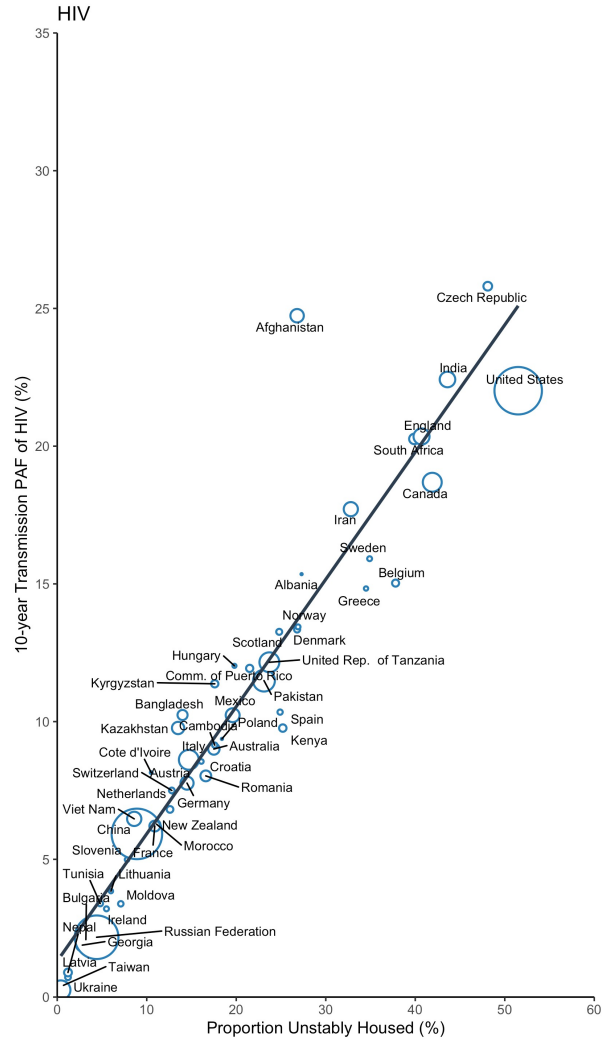
- tPAFs for HCV were typically higher than those for HIV because of the higher RR estimate for the effect of unstable housing on HCV transmission risk.
- The highest tPAFs for HIV and HCV were estimated in Afghanistan, Czech Republic, India, US, England and Wales
  - tPAFs > 20% for HIV
  - tPAFs > 25% for HCV

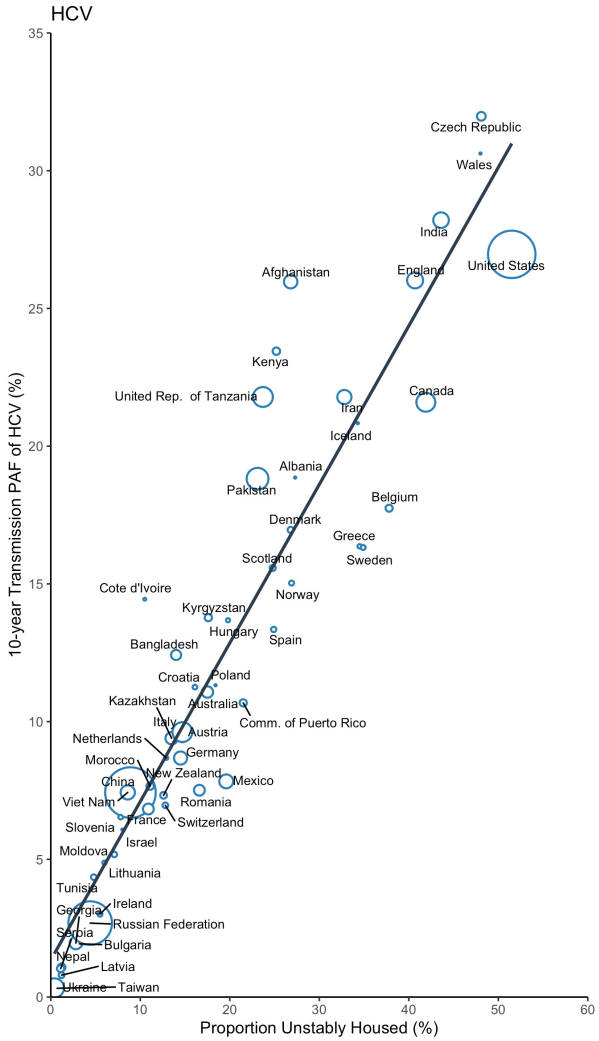
Contribution to the global number of infections attributable to unstable housing



- 6 Countries with highest tPAFs (Afghanistan, Czech Republic, India, US, England, Wales) contributed:
  - 29% of the global HIV infections attributable to unstable housing
  - 44% of the global HCV infections attributable to unstable housing.

- US contributes over a fifth of HIV infections attributable to unstable housing
- US contributes a third of HCV infections attributable to unstable housing





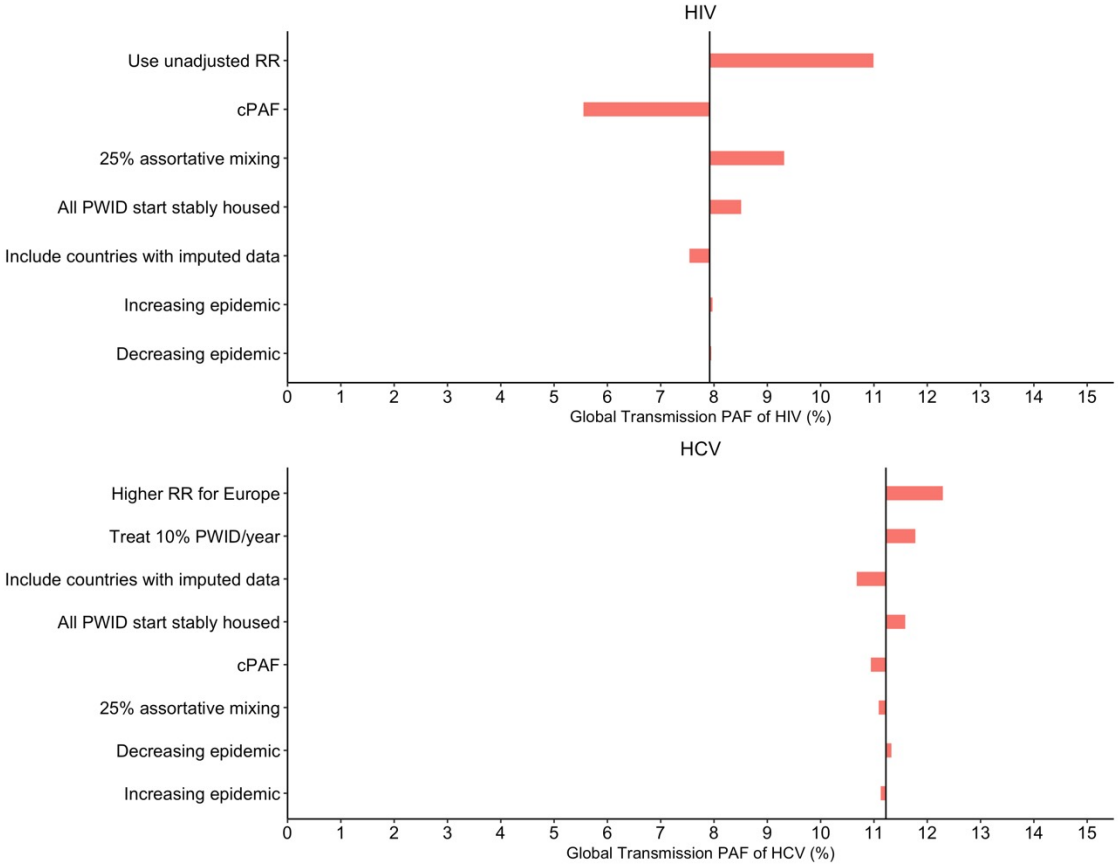
Between Country Heterogeneity

- Strong positive association between a country's median transmission PAF of unstable housing and the proportion of PWID that are unstably housed.
- Explained >88% of variability in tPAF estimates.

Sensitivity Analyses

- **The unadjusted estimate for the relative increase in HIV transmission risk if unstably housed were used (RR: 1·55, 85%CI: 1·23–1·95) rather than the adjusted estimate.**
- **For Western and Eastern European countries, the relative increase in HCV transmission risk was higher (RR: 2.06, 95%CI: 1.64–2.59) as found by Arum et al. This was the only region found to have a statistical difference in the RR for unstable housing.**
- PWID mixed partially (25%) assortatively by housing status rather than at random.
- All PWID start injecting as stably housed.
- The HIV or HCV epidemics were assumed to be increasing or decreasing; modelled by changing the HIV or HCV transmission rates by a relative 10% from the start of the 10-year PAF projections.
- 10% of HCV infected PWID are treated per year with direct acting antivirals.
- Include countries with insufficient data, imputing data for HIV/HCV prevalence and/or proportion that are unstably housed using regional estimates.
- Compared tPAFs with classical PAFs (cPAFs) - global cPAf was estimated by weighting national cPAFs by the estimated number of prevalent infections among PWID in each country.

Sensitivity Analyses



- Global tPAF for HIV was most sensitive to assuming the higher unadjusted relative risk of HIV transmission if unstably housed
  - Greatest effect in countries with higher baseline tPAFs, with the tPAFs for Czech Republic, Afghanistan, India and US increasing to >30%.
- The global tPAF for HCV was most sensitive to assuming the larger Europe specific relative risk of HCV transmission if unstably housed.
  - Effect was greatest in European countries with higher tPAFs, such that the tPAFs for Czech Republic, Wales and England increased substantially to 43.9%, 41.7% and 36.8%, respectively.
- Global tPAF greater than the cPAF, particularly for HIV – demonstrating importance of our approach that accounts for secondary infections.

Discussion

- Globally, unstable housing is projected to contribute an estimated 8% and 11% of new HIV and HCV infections among PWID over the next 10 years, respectively.
- These global estimates mask country and regional variation, which appears highly correlated to the level of unstable housing in each setting.
- For example, in Czech Republic, India, US, England and Wales, where at least 40% of PWID are unstably housed, unstable housing is projected to contribute more than 20% of new HCV and HIV infections.
- In contrast, in Taiwan, Georgia, Latvia, Ukraine and Nepal, where <3% PWID are unstably housed, unstable housing contributes at most 2% of new HIV/HCV infections.

Discussion

- Unstable housing is interlinked with many other social determinants of health, including incarceration, poverty, unemployment.
- Need to understand mechanisms for the elevated transmission risk associated with unstable housing and how interacts with other structural factors.
- Need to develop effective interventions to reduce these elevated risks
- Important to understand and quantify the other possible effects of unstable housing not modelled here
  - poorer access to and outcomes from HIV and HCV prevention and treatment
- **Efforts to achieve HIV and HCV elimination goals should not overlook the importance of implementing interventions and policies to reduce housing instability among PWID.**

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