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Improving our understanding of how structural determinants impact HIV epidemics: a scoping review of dynamic models to guide future research

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Background

Structural determinants of HIV: physical, social, cultural, organizational, community, economic, legal or policy features of the environment that facilitate or limit an individual's access to HIV prevention, treatment, or care

- Structural determinants influence HIV transmission through their effects on downstream mediators (Figure 1)

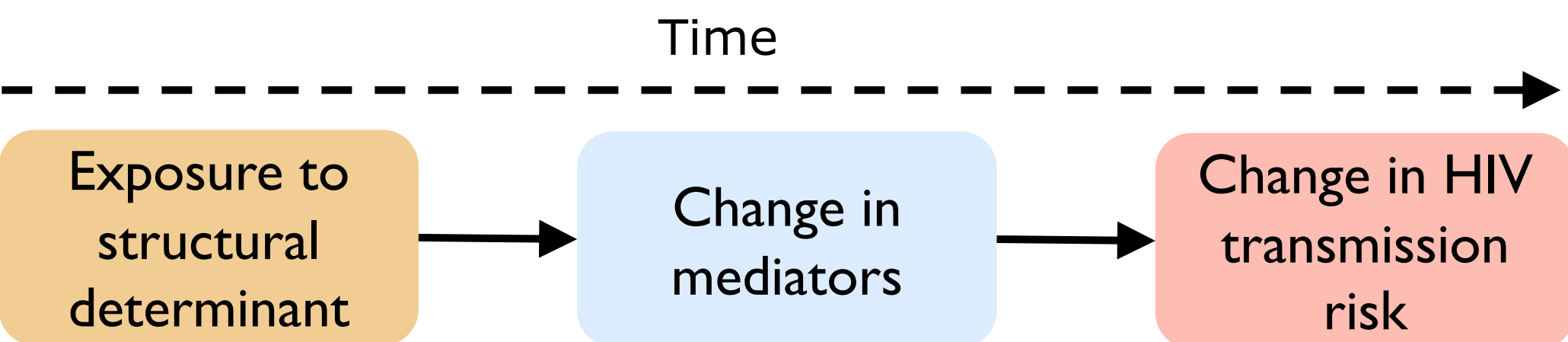


Figure 1. Causal pathway from structural determinant to HIV

- Modelling structural determinants is important to estimate their population-level impacts and inform efforts towards HIV elimination
- Challenges:** Limited understanding of the specific causal pathways and the magnitude of the effect of structural determinants on mediators and subsequent HIV risk

Aim

Improve methods to model structural determinants by:

- Identifying dynamic modelling studies that included structural determinants
- Appraising methods used to model structural determinants and their impacts

Methods

- Scoping review of PubMed for studies using dynamic transmission models of sexually transmitted and bloodborne infections that included structural determinants
- We extracted information on structural determinants and interventions modelled (e.g., exposure definitions, populations) and methods to model their impacts (e.g., counterfactual scenarios)
- We appraised studies based on how they:
 - Conceptualized exposure to structural determinants
 - Represented causal relationships over time
 - Defined counterfactual scenarios to measure the impact of structural determinants
 - Included persistent effects of exposure

Results - Search

- We identified 8 dynamic modelling studies of HIV, 2 of HCV and 1 that modelled HIV and HCV separately (Table 1)
- The main structural determinants were:
 - Housing instability/homelessness ($N_{\text{studies}}=2$)
 - Incarceration ($N_{\text{studies}}=4$)
 - Violence ($N_{\text{studies}}=3$)
 - Stigma ($N_{\text{studies}}=2$)

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Table 1. Table of studies identified in the scoping review that used dynamic transmission modelling to evaluate the contribution or impact of structural determinants or interventions

Reference	Region	Outcome	Populations modelled	Main structural determinants and interventions modelled
Levy, 2021	Africa (Kenya)	HIV	General population (not stratified by gender)	HIV stigma
Johnson, 2018	Africa (South Africa)	HIV	Heterosexual men and women (includes FSWs and clients), MSM	Education, incarceration, urban-rural migration
Rigby, 2017	Africa (South Africa)	HIV	Heterosexual women and men (includes FSWs and clients)	Intimate partner violence, violence-mitigation interventions
Goodreau, 2017	N America (USA)	HIV	Men who have sex with men	Sexual and HIV stigma, racial disparities in HIV
Altice, 2016	Europe (Ukraine)	HIV	PWID (not stratified by gender)	Incarceration, decriminalization of PWID
Shannon, 2015	Africa (Kenya), Asia (India), N America (Canada)	HIV	Female sex workers and clients (includes PWID)	Physical/sexual violence, safeness of work environment, police harassment, community organisation, decriminalisation of sex work
Strathdee, 2010	Africa (Kenya), Asia (Pakistan), Europe (Ukraine)	HIV	PWID (stratified by gender and key population)	Elimination of laws prohibiting OST and NSPs (Kenya and Pakistan), elimination of police beatings (Ukraine)
Bhunu, 2015	Specific setting not modelled	HIV	Homeless and non-homeless persons (not stratified by gender)	Homelessness, also access to entertainment, nutrition, and SES
Stone, 2021	N America (USA)	HCV	PWID (not stratified by gender)	Incarceration, decriminalization of PWID
Stone, 2017	Europe (Scotland)	HCV	PWID (not stratified by gender)	Incarceration, decriminalization of PWID
Stone, 2022	N & C America, Europe, Africa, Asia and Australasia	HIV and HCV (modelled separately)	PWID (not stratified by gender)	Unstable housing

FSW, female sex workers; HCV, hepatitis C virus; HIV, human immunodeficiency virus; IPV, intimate partner violence; N America, North America; N & C America, North and Central America; NSP, needle and syringe program; OST, opioid substitution therapy; PWID, people who inject drugs; SES, socioeconomic status.

Results – Appraisal of modelling studies

1. Exposure definitions

- Most models ($N=8$) assumed categories of fixed lifetime exposures or current, recent, and non-recent exposure that individuals could transition between

2. Causal pathways:

- Structural determinants were mostly assumed to ($N=7$) impact HIV transmission through mediated effects on one or more proximate risk factors (Figure 2)
 - e.g., condom use, number of secondary partners, treatment uptake

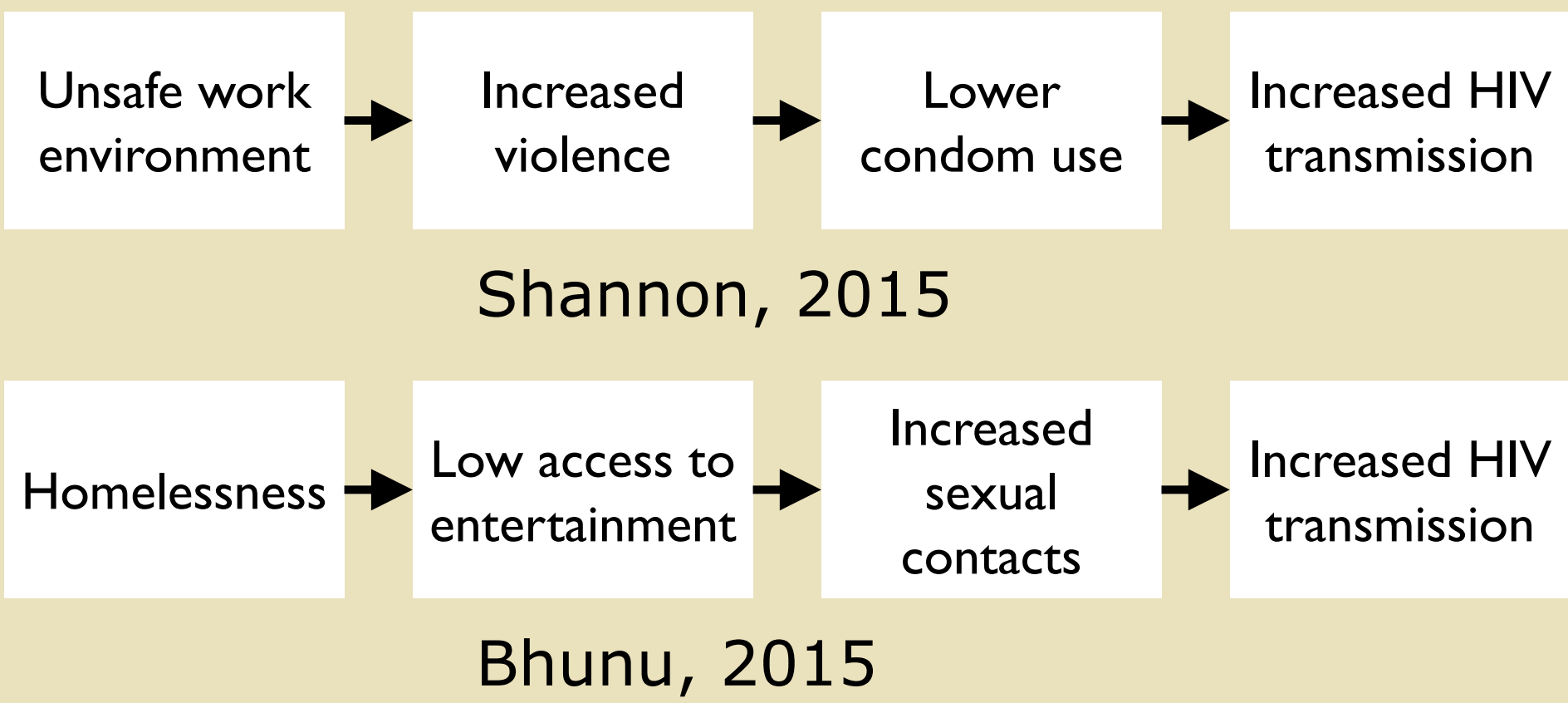


Figure 2. Example causal pathways from models

- In 4 studies, structural determinants were assumed to directly impact the transmission rate (i.e. no mediators)

3. Persistent effects of exposure

- Mostly assumed using categories of recent and non-recent exposure
- Models did not include delayed effects of exposure (i.e., that occur after a lag)
- Few models considered associations of past or recurring exposure with different transmission risks

4. Counterfactual definitions to measure impact

- To estimate the contribution of structural determinants or impact of interventions (e.g., decriminalization) studies mostly assumed reduced exposure in the future ($N=5$) or elimination of exposure ($N=4$) in counterfactual scenarios

Conclusions

- We found few studies that modelled structural determinants dynamically
- Methods are diverse and could be improved
- Coherent frameworks are needed to conceptualize the synergy between including structural determinants in models and strengthened empirical analysis
- Models should use refined exposure definitions and more precise estimates of causal associations with mediators

Recommendations

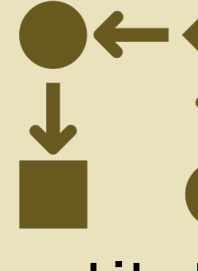
Including structural determinants in dynamic HIV transmission models

1. Adopt precise exposure definitions



- Consider severities, frequency, and duration of exposure

2. Deconstruct and estimate causal pathways



- Use quantitative and qualitative evidence of causal associations
- Consider proximate and distant mediators

3. Consider persistent effects of exposure



- Include persistent and delayed effects of exposure, and effects of past, recurrent, or acute exposure if there are associations with future transmission risks

4. Define appropriate counterfactual scenarios



- Counterfactual definitions should align with the goal of modelling (estimating the contribution of determinants vs impact of interventions)