Risk group turnover in STI/HIV epidemics

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2019 July 17

STI & HIV 2019 World Congress
Vancouver, BC, Canada

Disclosures

None.

Acknowledgements

NIH
CIHR IRSC
Johns Hopkins Bloomberg School of Public Health
MAP Centre for Urban Health Solutions
St. Michael's Inspired Care. Inspiring Science.
University of Toronto

SIR Models & Heterogeneity in Risk

- SIR Model:
  - $\mathcal{S}$ = susceptible, $\mathcal{I}$ = infectious, $\mathcal{R}$ = recovered
  - e.g. HIV
- 3 Risk Groups:
  - e.g. female sex workers, multiple partners, monogamous
  - fundamentally changes epidemic dynamics [1, 2]
  - what about: "retirement" from sex work, "recruitment" into sex work } Turnover

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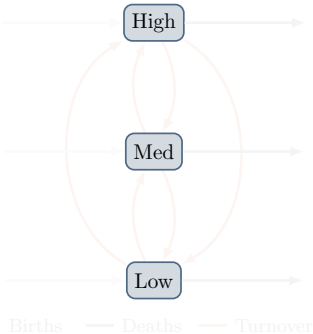

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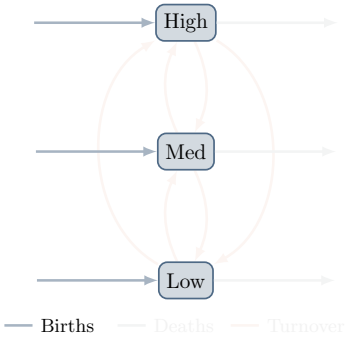

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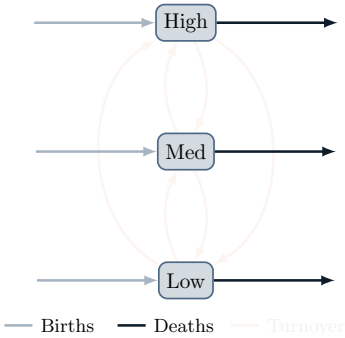

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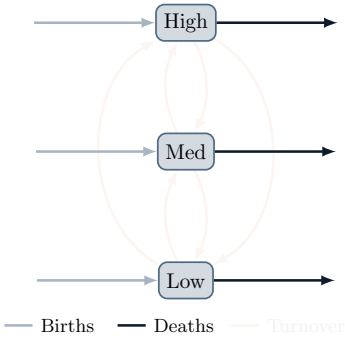

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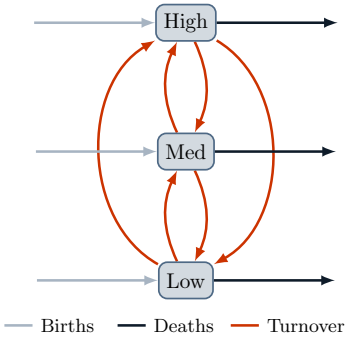

Risk groups

Influence of Turnover in STI Epidemic Models

Research Questions:

Influence of turnover on:

- Equilibrium incidence & prevalence by risk group
- TPAF * of high risk group

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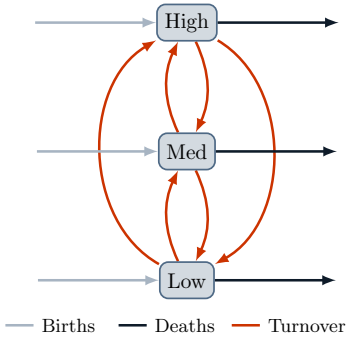
Proportion of cumulative new infections averted if transmission to / from that group is stopped.

e.g. impact of perfect TasP in one group



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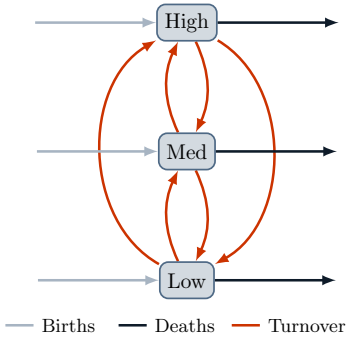

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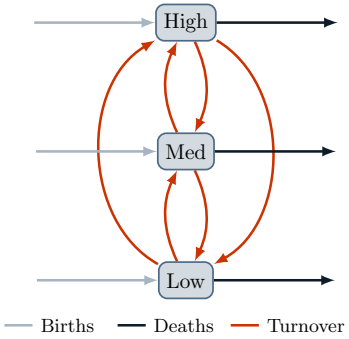

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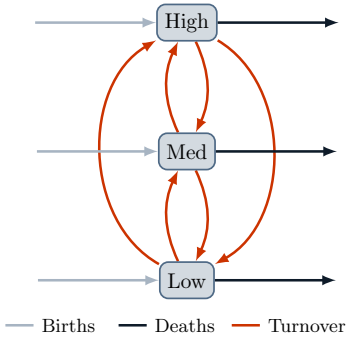

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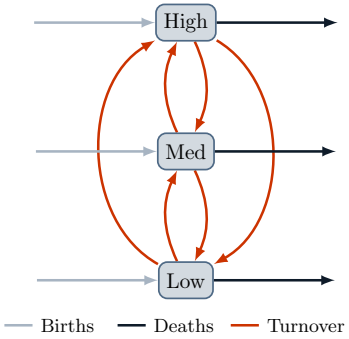

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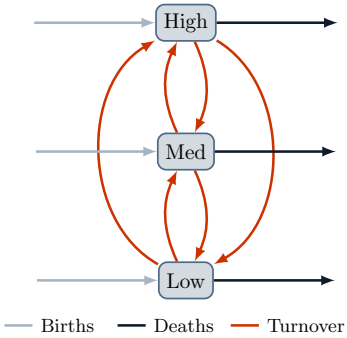
Illustrative Model of STI Transmission

- SIR model:
  - 1-sex
  - proportional mixing
  - same mortality across risk groups
- Risk group turnover:
  - Rates ensure group sizes don't change:
    5% High Risk, 20% Medium Risk, 75% Low Risk
  - All rates equal among: $\mathcal{S}$, $\mathcal{I}$, $\mathcal{R}$
  - All rates scaled proportionally when varied



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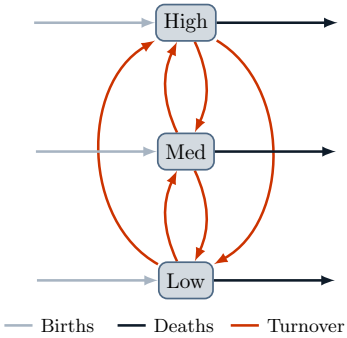

Experiments: Influence of Turnover on Model Outputs

1. Equilibrium outputs:
   - **Vary:** Turnover magnitude
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2. TPAF after model fitting:
   - **Fit:** Contact rates: High Risk; and Low Risk
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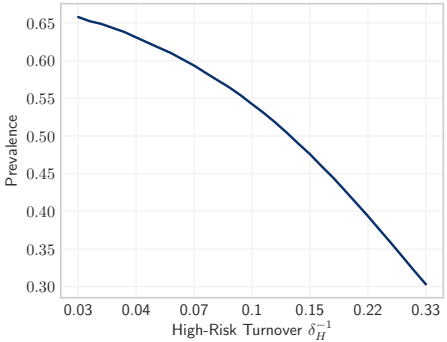

High risk prevalence vs turnover

Turnover causes a net movement of infected: high → low risk

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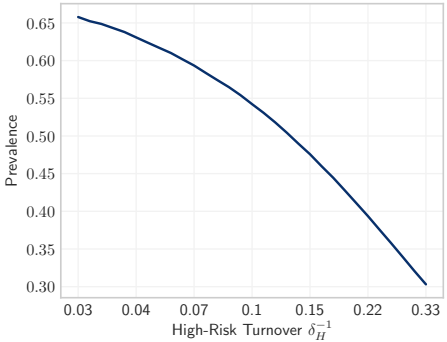

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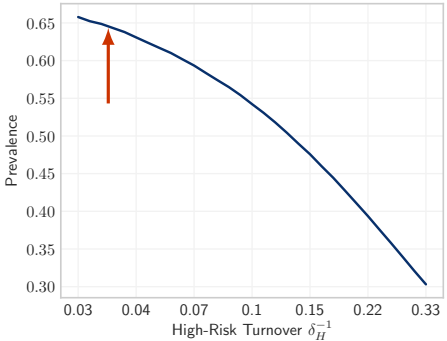

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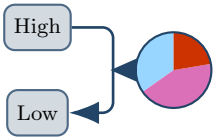

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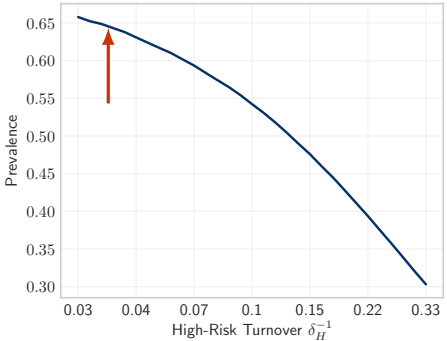

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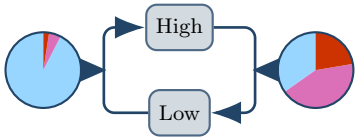

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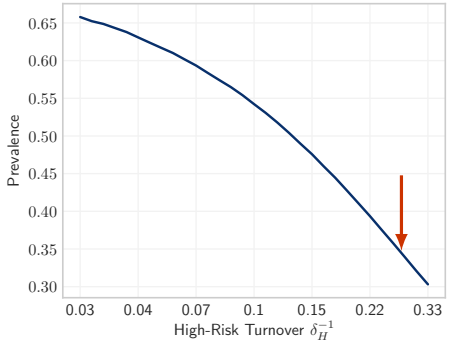

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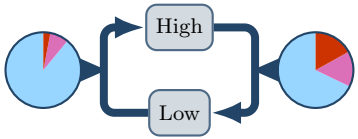

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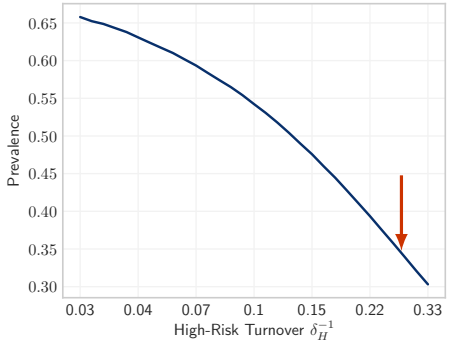

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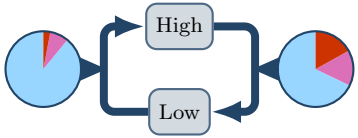

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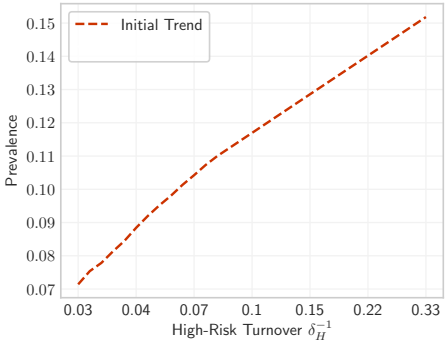

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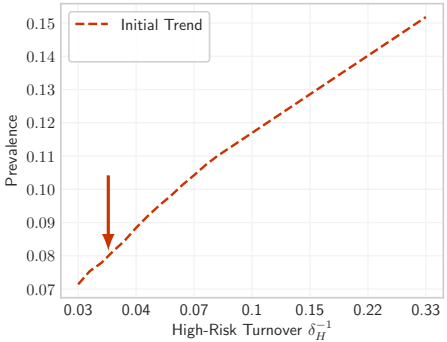

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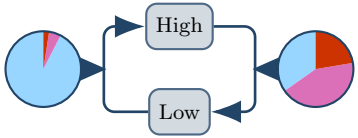

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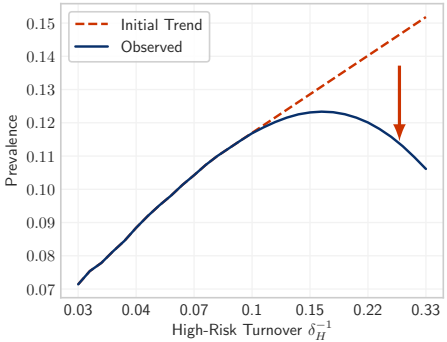

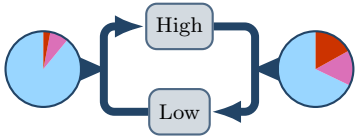

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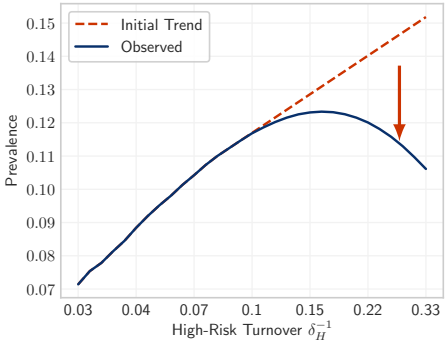

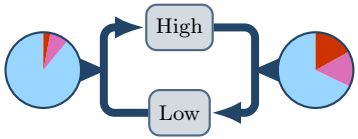

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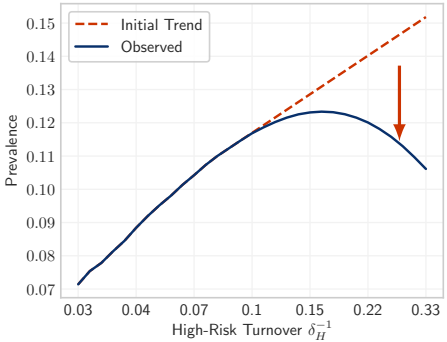

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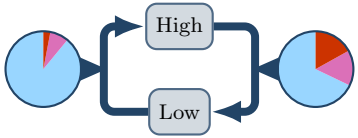

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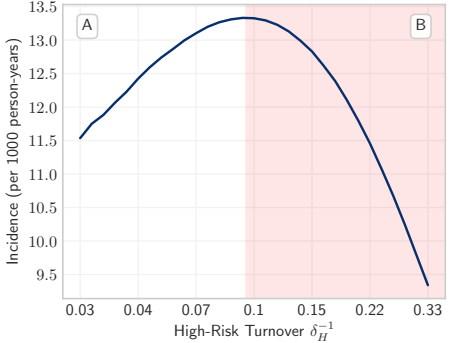

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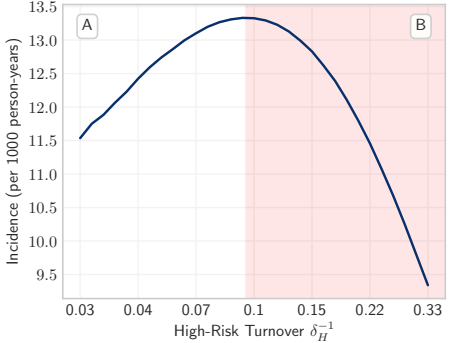

Overall incidence vs turnover

- Turnover ↑ proportion who are infectious
  - Dominates at low turnover (A)
  - Incidence ↑
- Turnover ↓ contact rate among infectious
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(explains low risk prevalence decline with high turnover)

Low turnover: ↑ incidence **High turnover: ↓ incidence**

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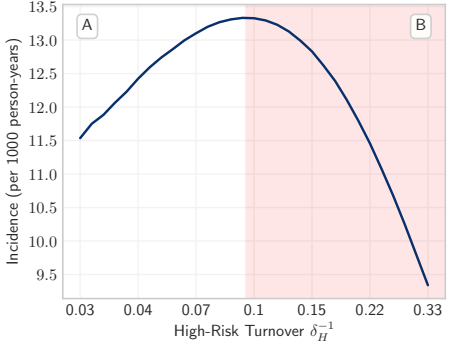

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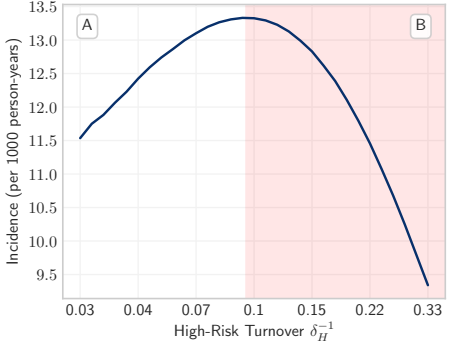

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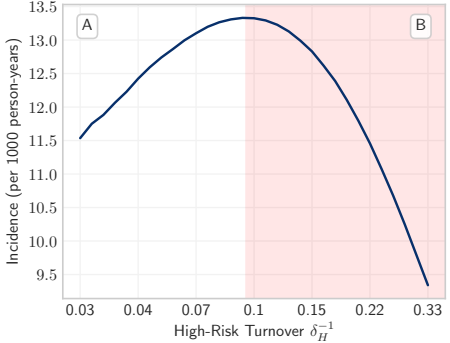

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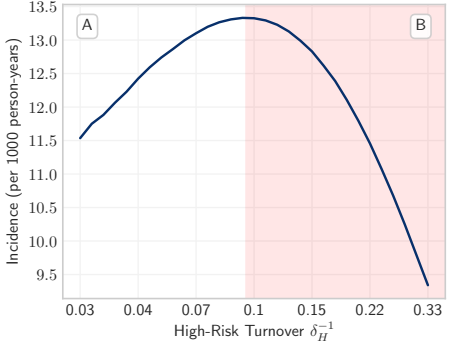
Low turnover: ↑ incidence **High turnover: ↓ incidence**

Two competing effects of turnover on incidence



Overall incidence vs turnover

- Turnover ↑ proportion who are infectious
  - Dominates at low turnover (A)
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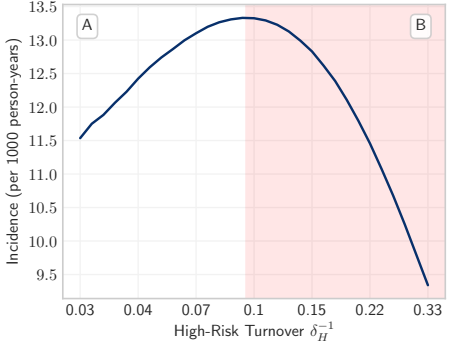

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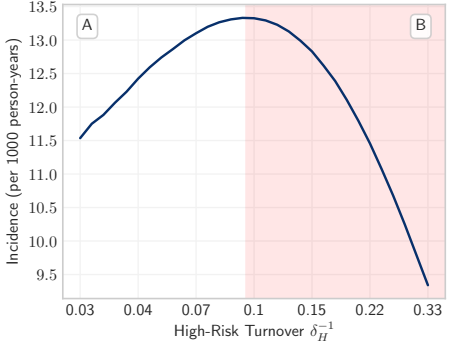

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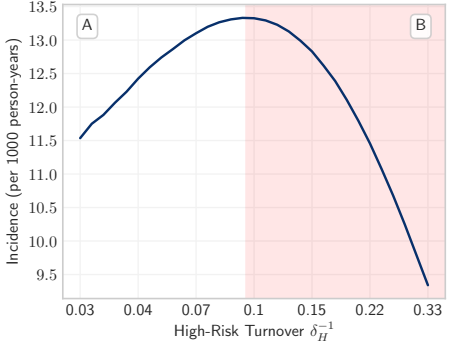

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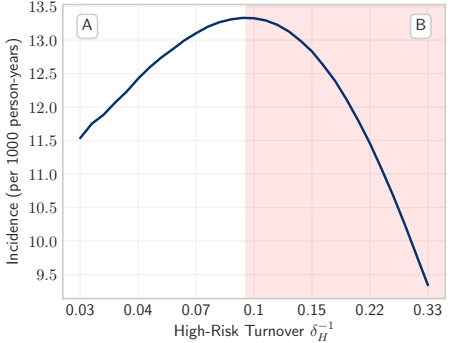

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Experiments: Influence of Turnover on Model Outputs

1. Equilibrium outputs:
   - **Vary:** Turnover magnitude
   - **Compare:** a) prevalence, b) incidence (by risk group, at equilibrium)

2. TPAF after model fitting:
   - **Fit:** Contact rates: High Risk; and Low Risk
   - **Targets:** Prevalence: 25% in High Risk; and 5% in Low Risk
   - **Vary:** No-turnover vs Turnover
   - **Compare:** a) Fitted contact rates, b) TPAF of high risk group

Turnover makes it "harder" to observe a high prevalence ratio

		No turnover	Turnover
Prevalence	High risk	25%	25%
	Low risk	5%	5%
	Ratio	5.0	5.0
Contact rate	High risk	15.8	16.9
	Low risk	2.49	0.28
	Ratio	**6.3**	**60**

To observe the same prevalence ratio:

Risk heterogeneity must be higher with turnover than without (overcome "homogenizing" effect of turnover)

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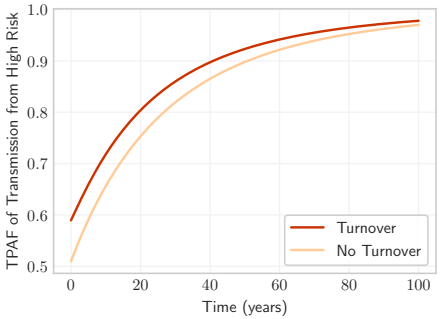

TPAF ≈ impact of perfect TasP in one group

- Risk heterogeneity (contact rate ratio) is higher with turnover
- Impact of reaching high risk group is higher with turnover

TPAF of high risk group may be underestimated if turnover is not modelled

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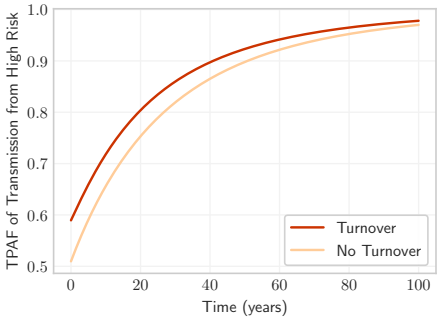

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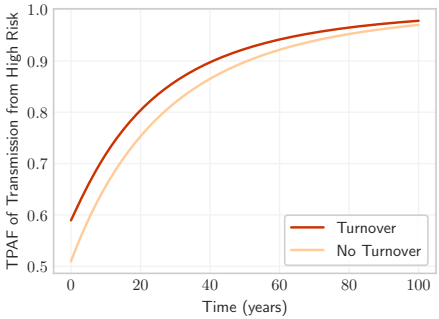

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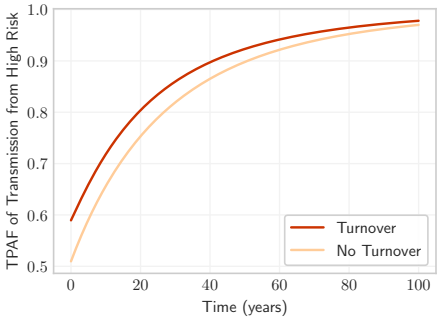

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- Results shown here conditional on model structure, assumptions, and parameters

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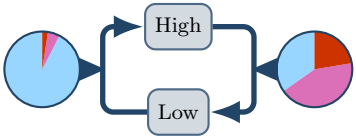
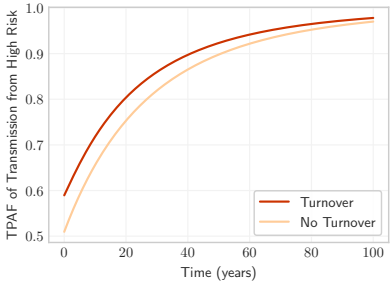

High
Low


TPAF of Transmission from High Risk
1.0
0.9
0.8
0.7
0.6
0.5
0
20
40
60
80
100
Time (years)
Turnover
No Turnover

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