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CONTACT PATTERNS BY AGE AND GEOGRAPHY WITH RECURRENT MOBILITY: INFLUENCE OF RELAXING ASSUMPTIONS

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BACKGROUND

- Contact patterns mediate dynamics of infectious diseases e.g. in transmission models stratified by **age** & geographic **patches** [1]
- Prem et al. [2] project age contact patterns onto 177 countries: "home", "work", "school", & "other" contacts from **POLYMOD**
- Arenas et al. [3] model patch/age contacts due to recurrent **mobility**: repeated daily travel between patches
- We built-upon [3] to integrate age contact patterns from [2], and relax 3 assumptions made in [3] — details in of our approach in [4]
- We explored the effect of each assumption on modelled contact patterns in the context of **reduced mobility** (April 2020)

RESEARCH QUESTION

How does each assumption below influence patch/age contact patterns?

Overall assumption in [3]: *fixed age pattern for all patches & contact types*
3 component **assumptions**:

A1. *Contact patterns are equal (averaged) across contact types*
A2. *Contact patterns are not adjusted to per-patch age distributions*
A3. *Contacts at "home" include visitors to the patch*

CONTEXT + DATA

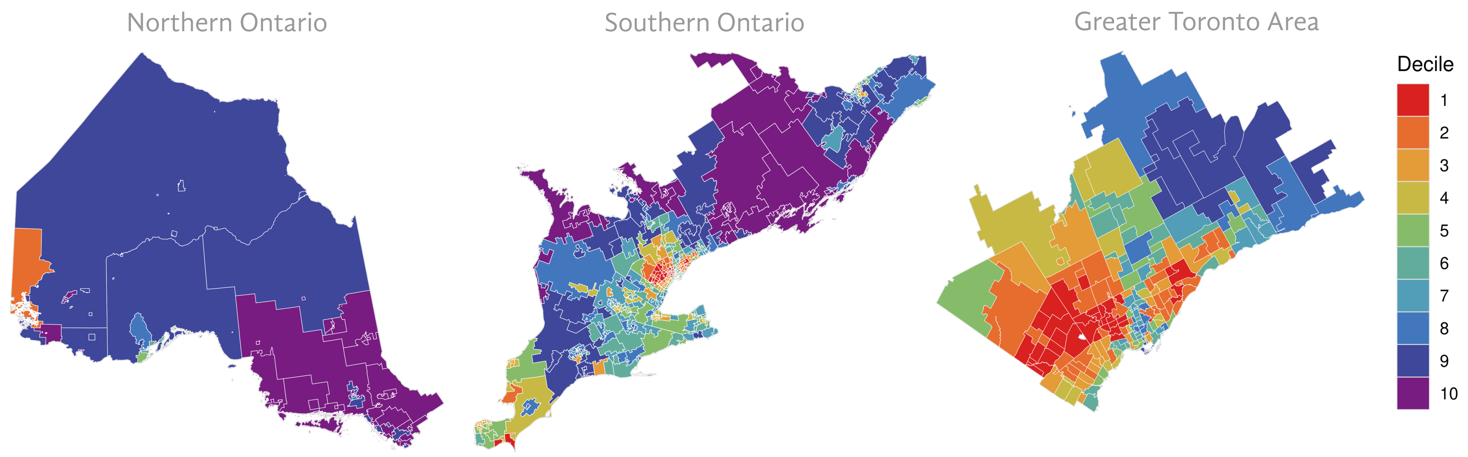

Figure 1. Map of 513 Ontario areas grouped into 10 patches (deciles) by COVID-19 incidence

Notation: g: self patch a: self age group y: contact type
g': other patch a': other age group

Main Output: $C_{gag'a'y}$: # daily contacts of type-y per-person formed from patch/age ga to patch/age $g'a'$

Context: 513 Ontario areas grouped into 10 patches by COVID-19 incidence (Figure 1) & population stratified into 5-year age groups

Data:

- Population distribution by age and patch $P_{ga} \leftarrow$ Census [5]
- Mobility matrix $B_{gg'} \leftarrow$ Cell phone data [6]
 % residents who travelled from g to g' daily, including within-patch & % reduced mobility during t = April 2020 vs Jan–Feb 2020 (REF)
- Age contact patterns $C_{aa'y} \leftarrow$ Prem et al. [2]
 # daily type-y contacts per-person from age group a to a'

METHODS

Estimating $C_{gag'a'y}$: # daily type-y contacts per-person from patch/age ga to patch/age $g'a'$:

- Define two types of "mixing pools" (Figure 2):
  1. **Home pools:** can only contact other residents of this patch
  2. **Travel pools:** can contact anybody currently present
- For each contact type y & patch g^*:
  - Population from g' present in travel pool: $P^{g^*}_{g'a} = B_{g'g^*} P_{g'a}$
  - Adjust age contact patterns $C_{aa'y}$ to $P^{g^*}_{g'a}$ per [7]
  - Assume random mixing by patch gg' within pool
- Assume reduced mobility → reduced non-home contacts
- Sum contacts from all patch g^* pools → Total contacts $C_{gag'a'y}$

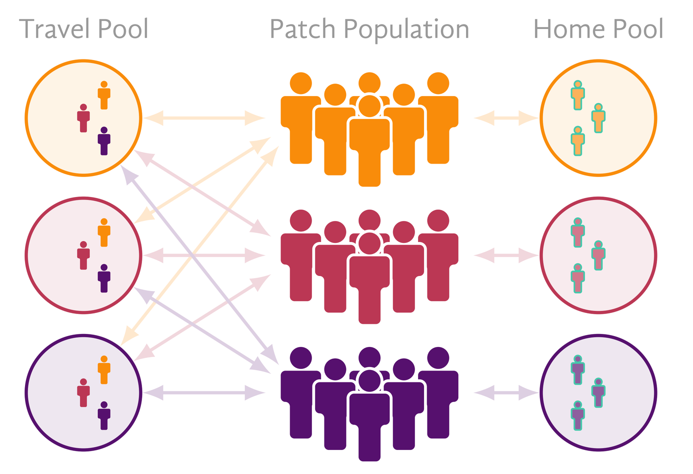

Figure 2. Illustration of travel vs home mixing pools for 3 toy patches

Experiment: We estimated & compared (subtracted) $C_{gag'a'y}$ under different sets of assumptions:

- (A1+A2+A3) subtract (A2+A3) → assumption A1 effect
- (A2+A3) subtract (A3) → assumption A2 effect
- (A3) subtract (·) → assumption A3 effect

We aggregated $C_{gag'a'y}$ across patches/ages to show overall patterns by age aa' or patch gg'

RESULTS

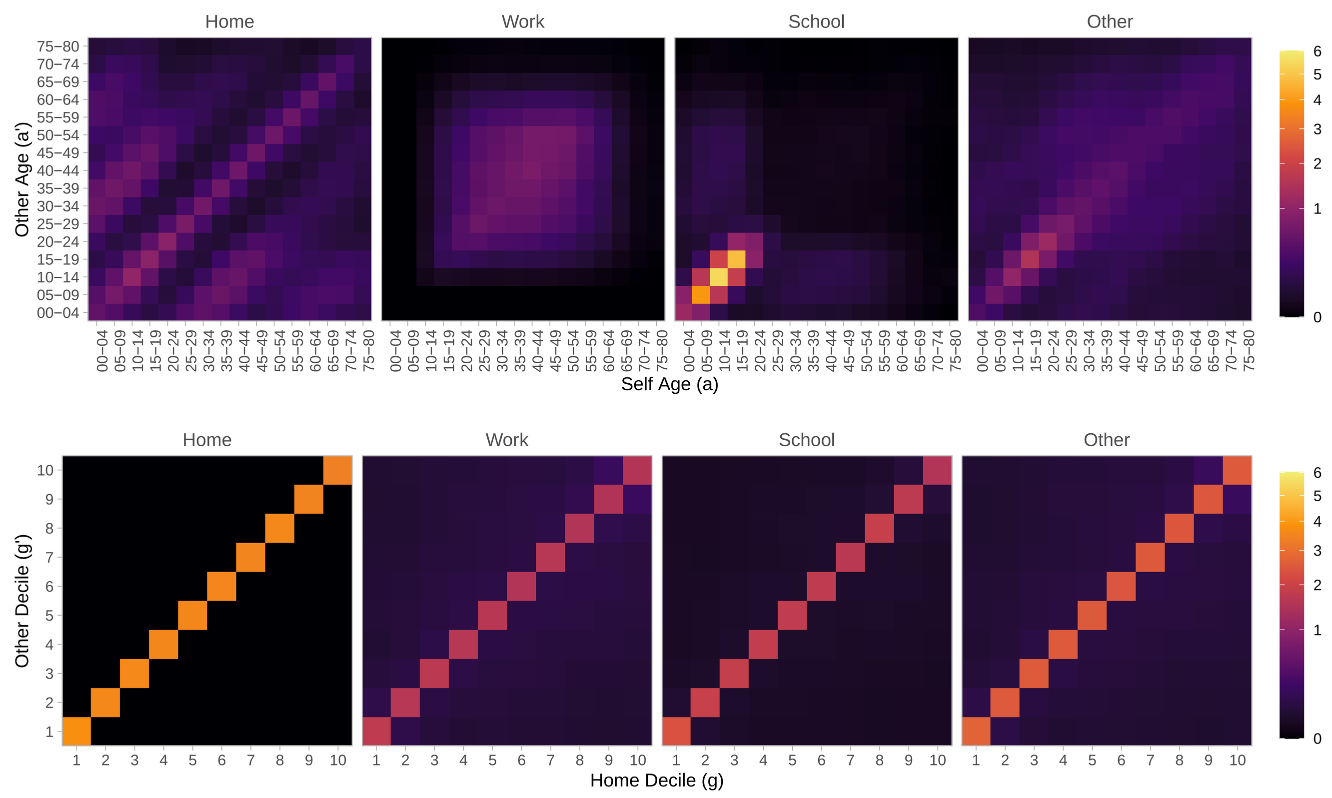

Figure 3. # daily contacts per person, stratified by type, after relaxing all 3 assumptions

(a) Age patterns: similar to inputs from [2]
- intergenerational contacts at home
- roughly random mixing at work
- like-with-like at school
- roughly like-with-like elsewhere

(b) Patch (decile) patterns:
- within-patch contacts dominate due to within-patch mobility & home pools
- inter-patch also roughly like-with-like

* Colour scale is square-root-transformed to improve perception of small values

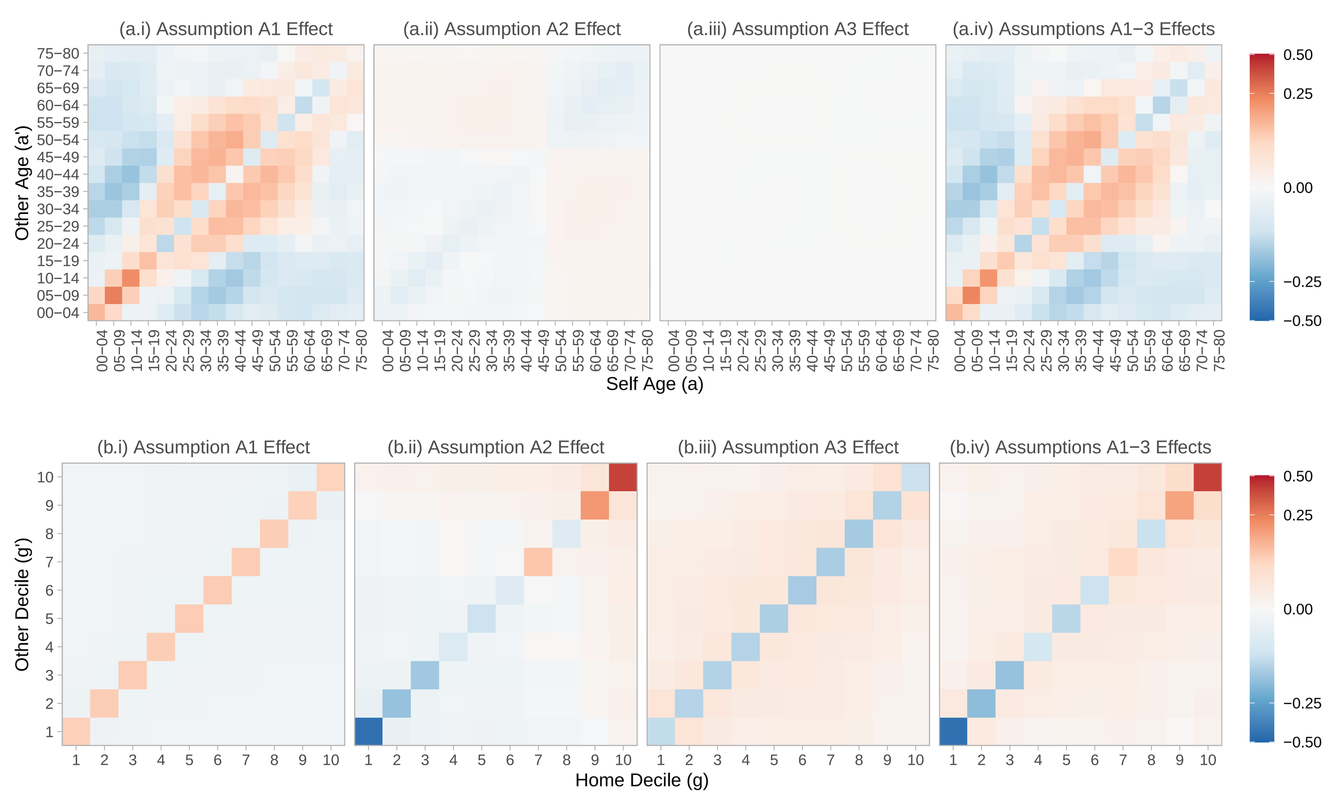

Figure 4. Differences in # daily contacts per person (all types) estimated with vs (minus) without each assumption

(a) Differences in age patterns by A1-3:
A1. non-home contacts overrepresented
A2. patch-specific effects (not shown)
A3. no effect

(b) Differences in patch patterns by A1-3:
A1. within-patch contacts overrepresented
A2. older patches' contacts overrepresented
A3. inter-patch contacts overrepresented

Positive: overestimation with assumption
Negative: underestimation with assumption
* Colour scale is square-root-transformed to improve perception of small values

SUMMARY OF ASSUMPTION EFFECTS

A1. If contact patterns averaged across types (Figure 4.i)
→ overestimate like-with-like age patterns from school/work
→ underestimate inter-generational contacts from home

A2. If contact patterns not locally age-adjusted (Figure 4.ii)
→ overestimate contacts with smaller age groups
→ underestimate contacts with larger age groups

A3. If contacts at home can include patch visitors (Figure 4.iii)
→ overestimate contacts formed with other patches
→ underestimate contacts formed within same patch

INTERPRETATION

- Fixing age patterns for all patches & contact types **may underestimate intergenerational home contacts** during reduced mobility
- Not adjusting contact patterns to per-patch age distributions **may over/underestimate overall contacts in different patches**
- Predominance of home contacts & within-patch mobility may result in **relatively few contacts between patches**
- Assumptions about contact patterns may influence model-based evaluations of **patch/age-targeted interventions** for infectious diseases
- Our approach to estimate contact patterns **integrates empiric contact patterns and mobility data**, and thus reduces the required assumptions

THANKS

Kristy Yiu, Gary Moloney, Linwei Wang, Yue Chen, Ruth Mwatelah, and Collin McGuire for helpful discussions and technical support; Prem et al. [2] for open-sourcing analysis code and numerical results.

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EPIDEMICS8 ONLINE LIVE AND ON-DEMAND 30 November – 3 December 2021
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