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Design of an optimal COVID-19 surveillance protocol for child care facilities using an infection spread model

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Background

- Investigate COVID-19 infection spread in day care centers for children (DCC) during a pandemic
- Negative effects for children are associated with the closure of DCCs
- Clinical studies of DCC during a pandemic are limited
- Design of optimal surveillance protocol needed using computational simulations

Hypothesis: Resolving DCCs while simultaneously providing surveillance testing might be feasible

Model Structure:

- Model of a DCC consists of three distinct roles:
 - Supervisors (Head)
 - Childcare workers (CCW)
 - Children with/without permission for testing
- Children groups are mostly isolated but can interact via shared rooms (e.g. bathrooms)
- CCWs can interact between CCWs from other groups via a shared common room
- CCWs regularly interact with the head of the DCC
- Intergroup infections are more common than intragroup infections

Structure of Model DCC:

Individual-based model

- Stochastic individual-based model [1] based on a modified SEIR model [2] with states susceptible, infected, quarantined, isolated and immune
- Individuals can move between states governed by transition rates given by [2] and [4]
- Green and red arrows indicate policy-specific and virus-specific transition rates respectively

Viral load and infection transmission

- Infection spread between individuals (in red) is modeled using a transmission risk calculator [2] based on the current viral load given by a viral load kinetic model [2]
- The viral load kinetic model [2,4] is given by a piecewise linear function, which depends on the age and is different for asymptomatic and symptomatic infected

Results

Parameters:

- 400 000 simulation with a duration of 30 days
- Children are on average 8 hours together in the DCC
- Infection risk parameters from aerosol transmission from [3]

Quarantine Policies:

- Regular: Whole group goes into quarantine if one positive test
- Limited: Only individuals with a positive result are isolated

Measurement: Average number of secondary infections (ASI)

Surveillance Test:

- Test type: PCR test
- Limit of detection: 1000 viral copies per ml
- Time until test result is available: 12 hours

Screening:

- Test frequency
- Children participation rate

Conclusion

- Monday is an optimal test day
- Not much difference between three times testing and daily testing (Mo-Fr)
- Infected CCWs cause more secondary infections than infected children due to higher viral loads and infection spread
- Limited quarantine policy is a feasible strategy for a least 50 % children participation and two times testing per week
- PCR testing is only feasible with a short waiting time

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