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Krankheitsausbreitungs- und Netzwerksdaten für die Covid-19-Simulation

Niki Popper, Martin Bicher

TU Wien, Forschungsbereich Information und Software Engineering

Modelling an Impact

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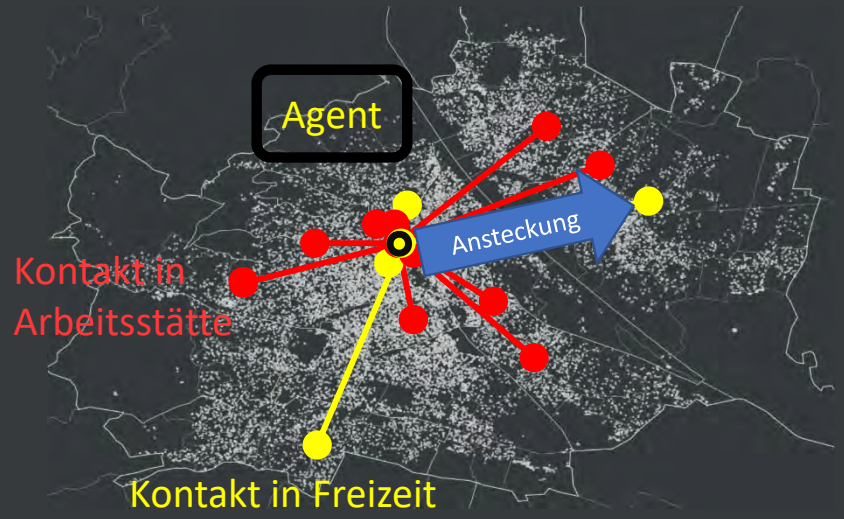

[1] M. Bicher, C. Urach, und N. Popper, „GEPOC ABM: A Generic Agent-Based Population Model for Austria“, in Proceedings of the 2018 Winter Simulation Conference, Gotheburg, Sweden, 2018

[2] F. Miksch, B. Jahn, K. J. Espinosa, J. Chhatwal, U. Siebert, and N. Popper, “Why should we apply ABM for decision analysis for infectious diseases?—An example for dengue interventions,” PLoS ONE, vol. 14, no. 8, p. e0221564, Aug. 2019, doi: 10.1371/journal.pone.0221564

[3] G. Schneckenreither and N. Popper, “Dynamic multiplex social network models on multiple time scales for simulating contact formation and patterns in epidemic spread,” in Proceedings of the 2017 Winter Simulation Conference, Las Vegas, Nevada, 2017, pp. 4324–4335 and F. Miksch, G. Zauner, N. Popper, and F. Breitenecker, “Agent-Based Population Models For Household Simulation,” in Proceedings of the 7th EUROSIM Congress on Modelling and Simulation, Prague, Czech Republic, 2010, vol. Vol. 2 Full Papers (CD), pp. 567–572.

GIS Information of Population

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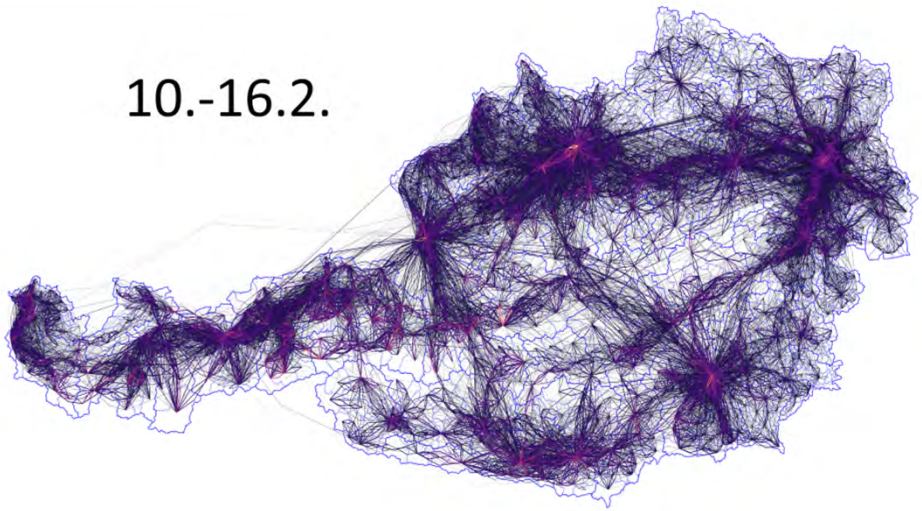

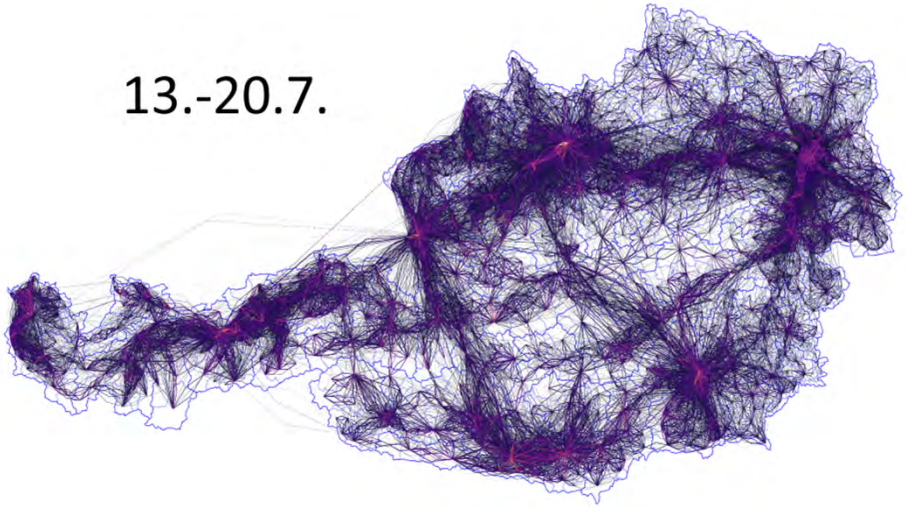

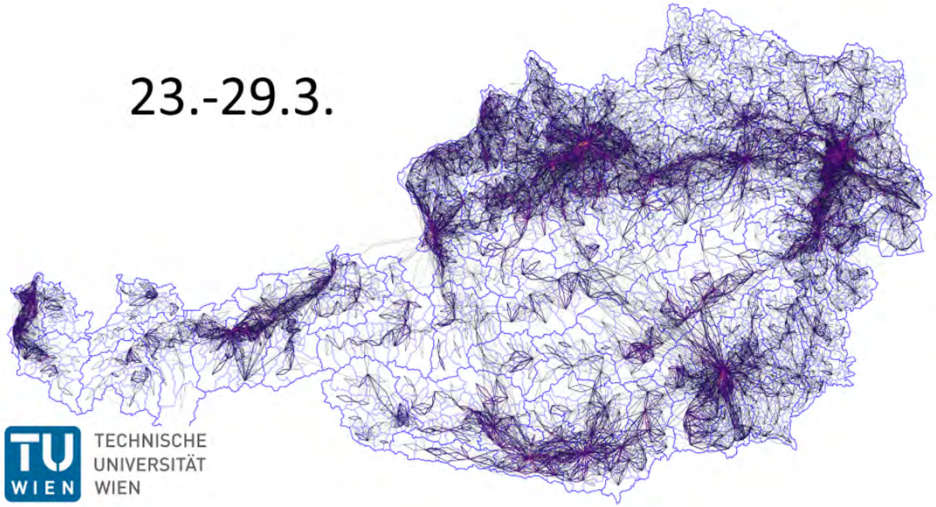

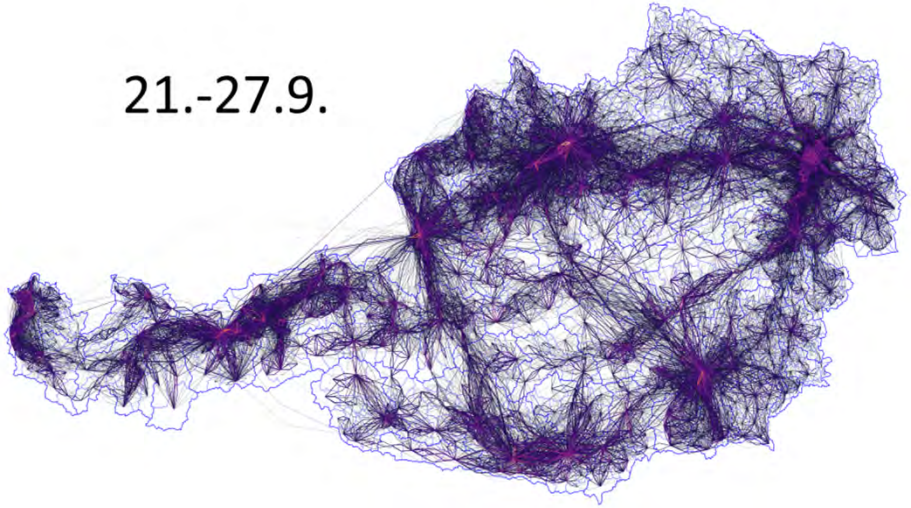

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Pathways of Patients

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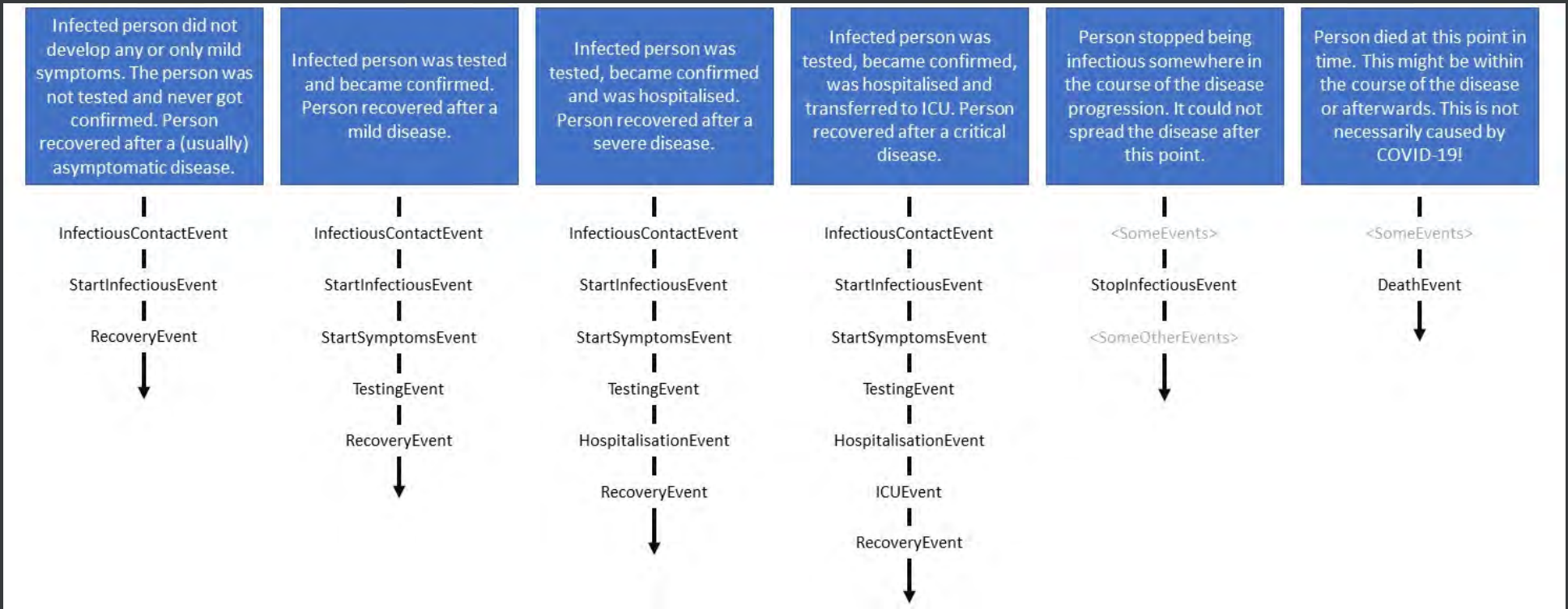

Data Acquisition (EMS, Sentinella, Cluster)

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EMS (= epidemiologisches Meldesystem):

- Doctors/Labs have to report positive cases
- Report includes: Age, Gender, District, Stay at Hospital/ICU
- Difficulties:
  - Backdated data
  - Hospital/ICU stay not always updated
  - Recovery Date when patients stay at home

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	ID	dDiag	dMeld	dKrank	dTod	Datum	DatumSpezial	Geschlecht	Alter	IntensivStation	Hospitalisiert	Tot	GeheiltDatum	aGKZ	Zeitpunkt	AutoGeheilt
233	316084	10.03.2020	10.03.2020	09.03.2020		11.03.2020	10.03.2020	M	58	FALSE	FALSE	FALSE	28.03.2020	70218	30.06.2020	FALSE
234	316092	11.03.2020	11.03.2020	10.03.2020		11.03.2020	11.03.2020	M	48	FALSE	FALSE	FALSE	20.03.2020	60101	30.06.2020	FALSE
235	316102	09.03.2020	11.03.2020	09.03.2020		11.03.2020	09.03.2020	W	23	FALSE	FALSE	FALSE	24.03.2020	92201	30.06.2020	FALSE
236	316105	11.03.2020	11.03.2020	09.03.2020		11.03.2020	11.03.2020	W	27	FALSE	FALSE	FALSE	28.03.2020	922	30.06.2020	FALSE

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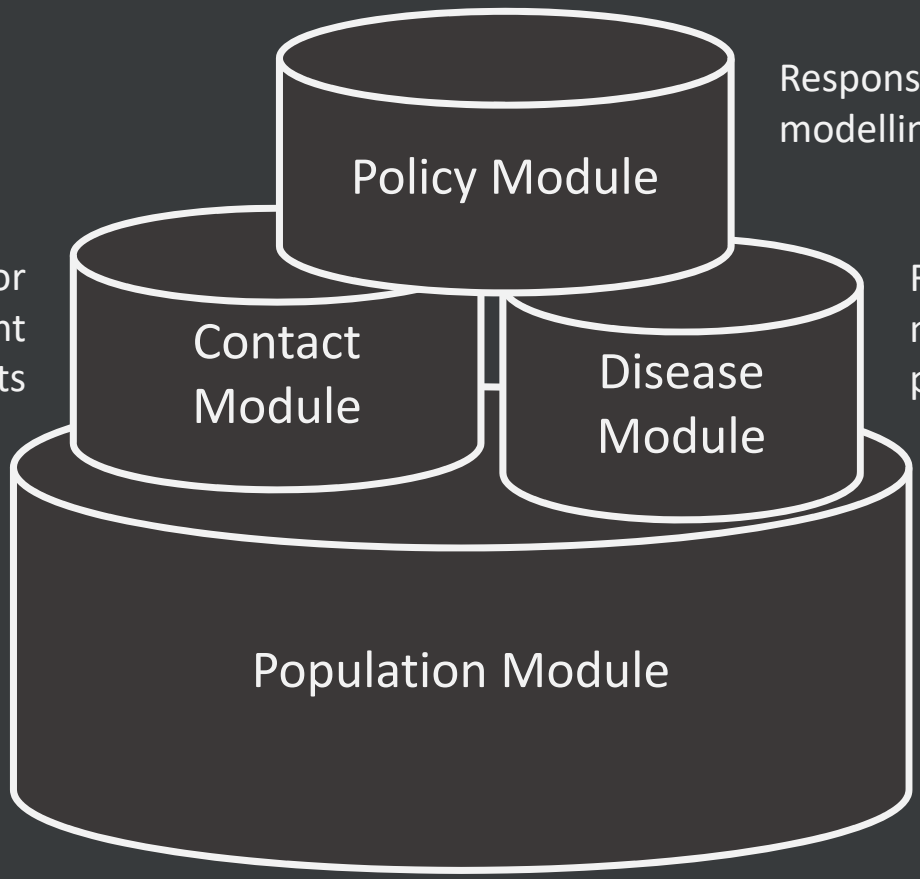
Model Overview



Responsible for modelling of policies

Responsible for creating agent-agent contacts

Responsible for modelling the disease progression

Responsible for creating and managing agents as well as death and birth processes

Model Overview

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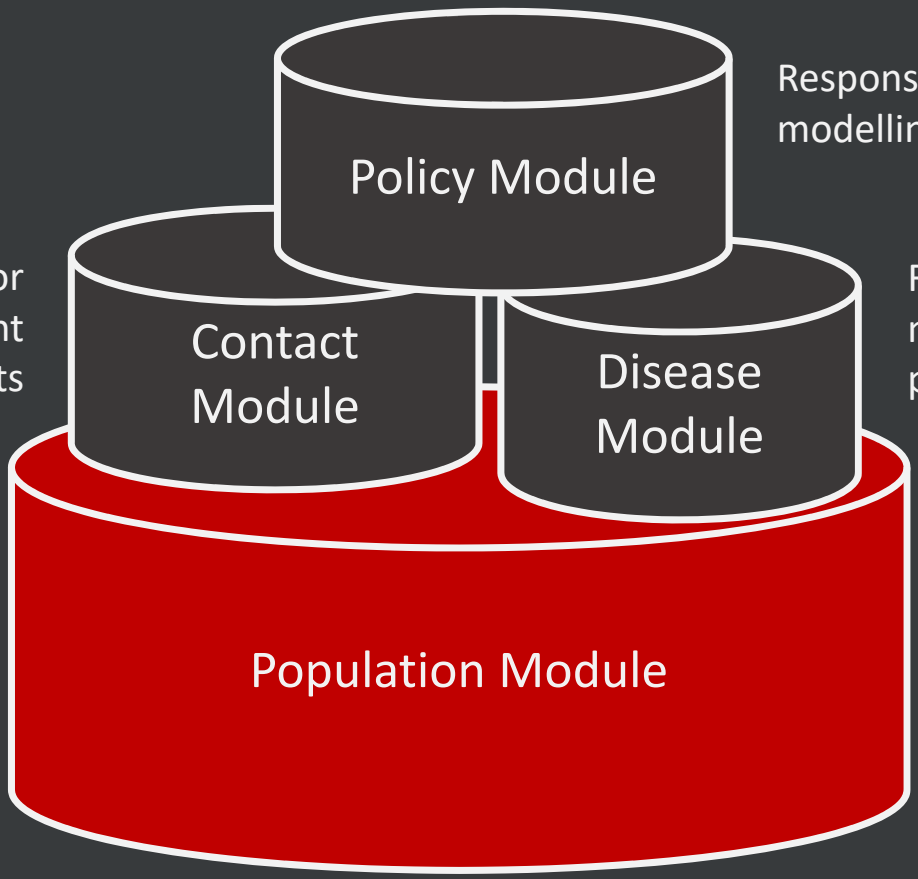

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Population Module: GEPOC

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Generic

It can be used to tackle any reasearch problem that is related to a country‘s population

Population

It depicts the state of the art and future development of a country‘s inhabitants.

Concept

It consists of several models, implementations, toolboxes and a rich data-base

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What is GEPOC?

Key concept:
Every real inhabitant is repesented by a statistically representative virtual inhabitant (a so called agent)

Statistical sampling

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Why do we need a virtual inhabitant?

With a virtual inhabitant, we can do lots of things we cannot do in reality.

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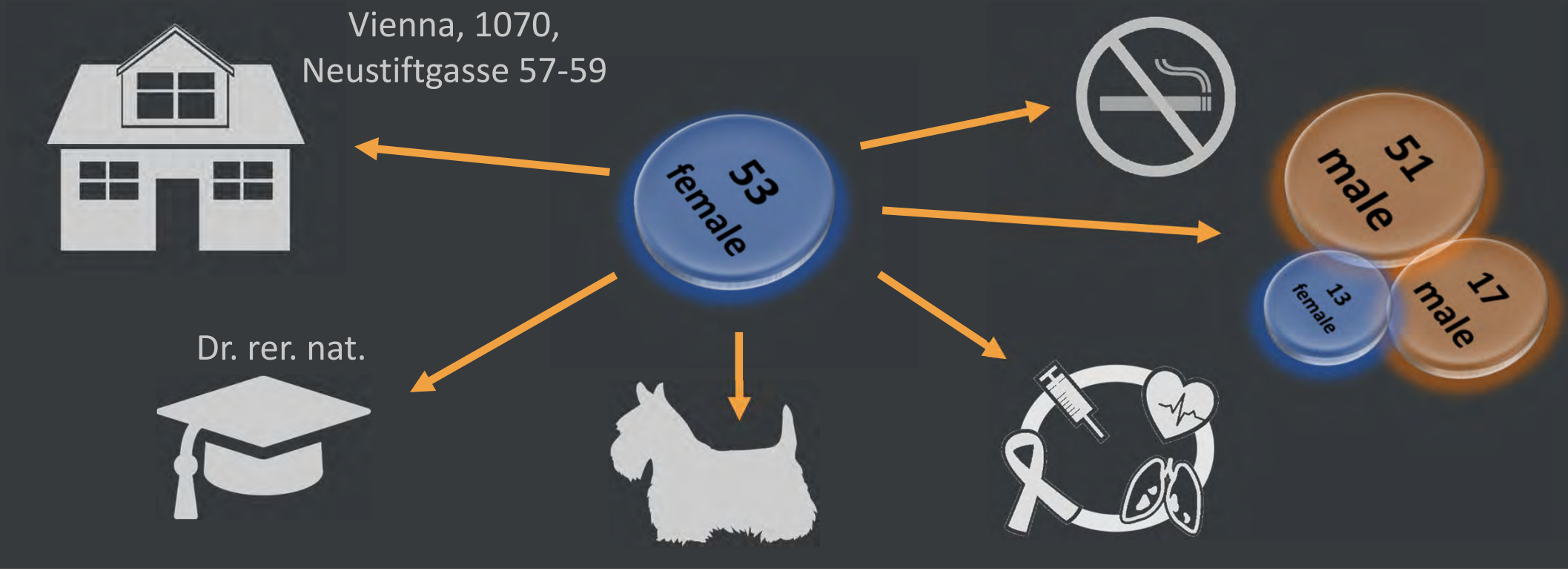
What can we do with a virtual inhabitant?

We can give it a place to live, a financial well-being, a job, a level of education, a chronic disease, a family, ...



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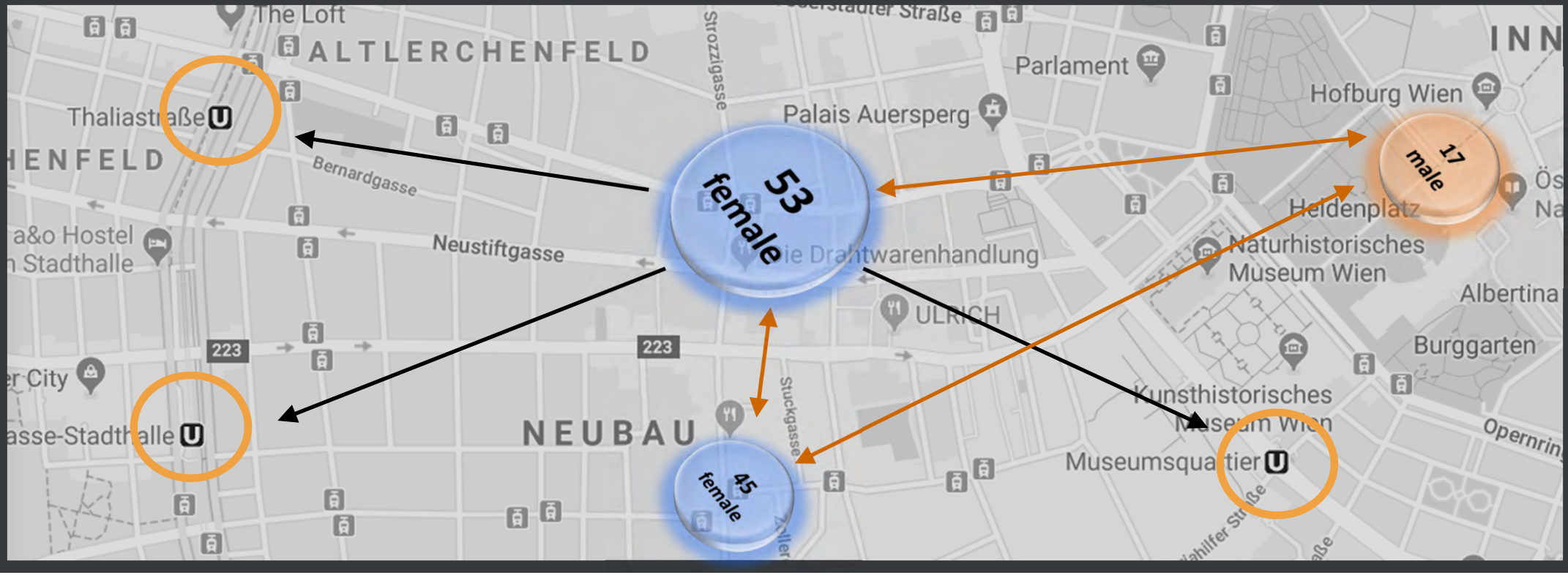
What can we do with a virtual inhabitant?

… explore it‘s environment and it‘s interactions.



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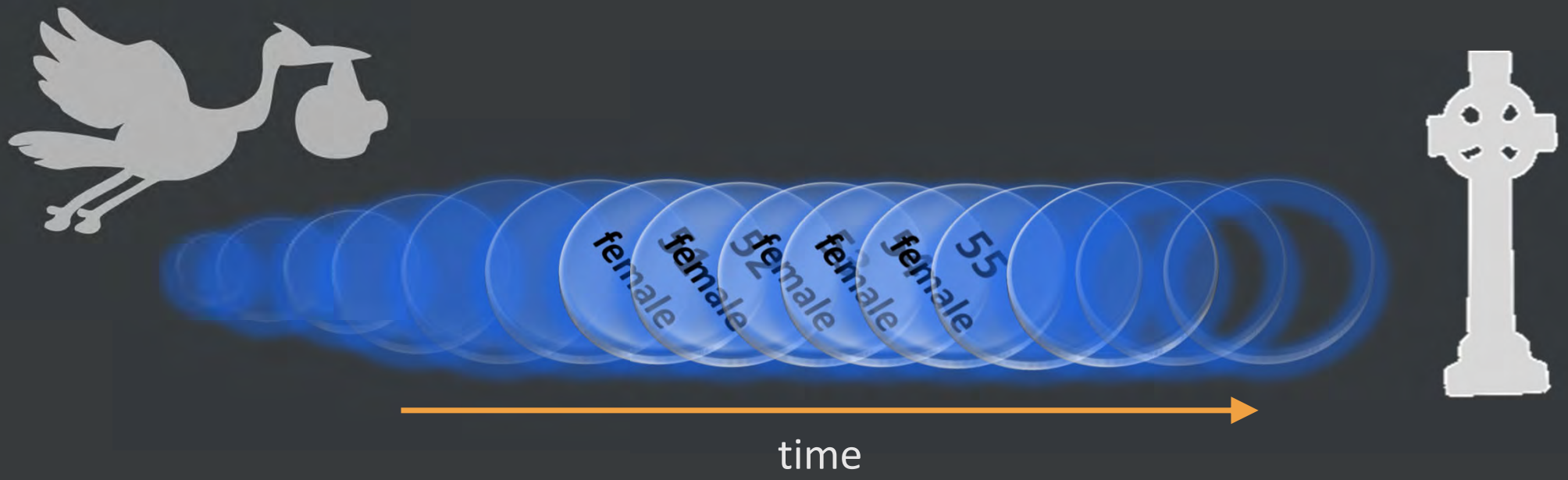
What can we do with a virtual inhabitant?

We can trace it - wherever and whenever!



GEPOC Base Model: Data and Validation

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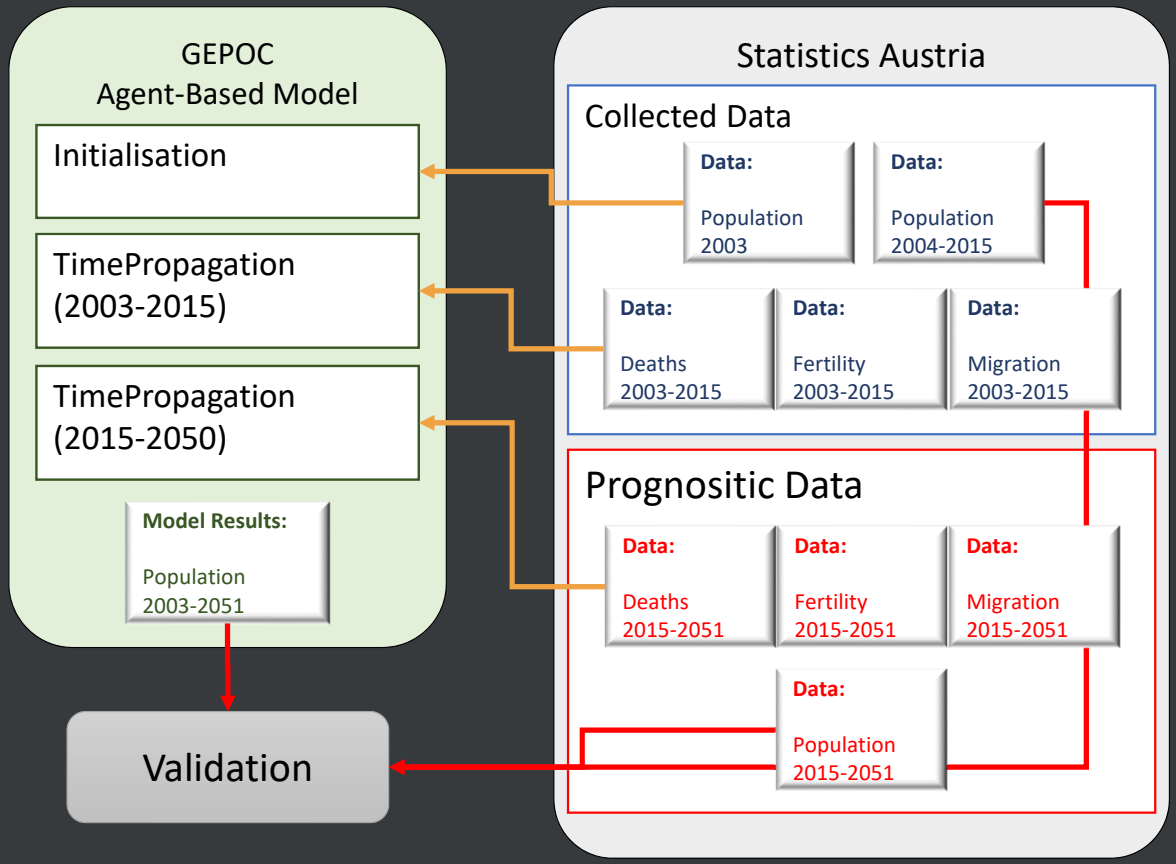

Both, validation and parametrisation data originates from Statistics Austria.

- GEPOC Base validly depicts the population of Austria since 1998
  (Errors <1%)
- It generates forecasts that match the forecasts of Statistics Austria until 2100

GEPOC Geography Toolbox

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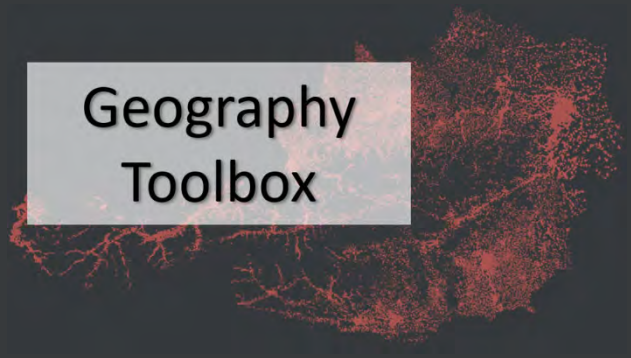

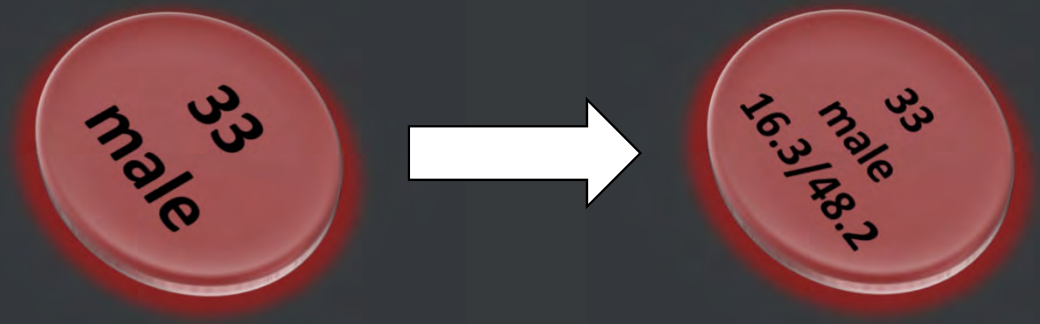

Features:

- Randomly samples residences for individuals in form of **GIS coordinates**
- Sampled points according to defined distributions on different regional levels (Federal States, Districts, Municipalities,...)

Uses a highly innovative, and efficient sampling algorithm that guarantees a highly realistic population distribution.

Residence-Sampling Algorithm

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Regional distributions from
Statistics Austria

	A	B	C	D	E	F	G
1	iso	name	2002	2003	2004	2005	
39	319	Sankt Pölten (Land)	118448	118829	119550	120614	12
40	320	Scheibbs	41135	41043	41149	41358	4
41	321	Tulln	89090	89718	90268	91038	9
42	322	Waidhofen an der Thay	28133	27890	27792	27655	2
43	323	Wiener Neustadt (Land	71891	72002	72446	72834	7
44	325	Zwettl	45448	45187	45014	44845	4
45	401	Linz (Stadt)	182304	183827	185172	186781	18
46	402	Steyr (Stadt)	39415	39111	39164	39093	3
47	403	Wels (Stadt)	56842	57473	57714	58064	5
48	404	Braunau am Inn	95025	95269	95331	95901	9

Data Linkage

Detail Information about inhabited areas
from Global Human Settlement Layer data

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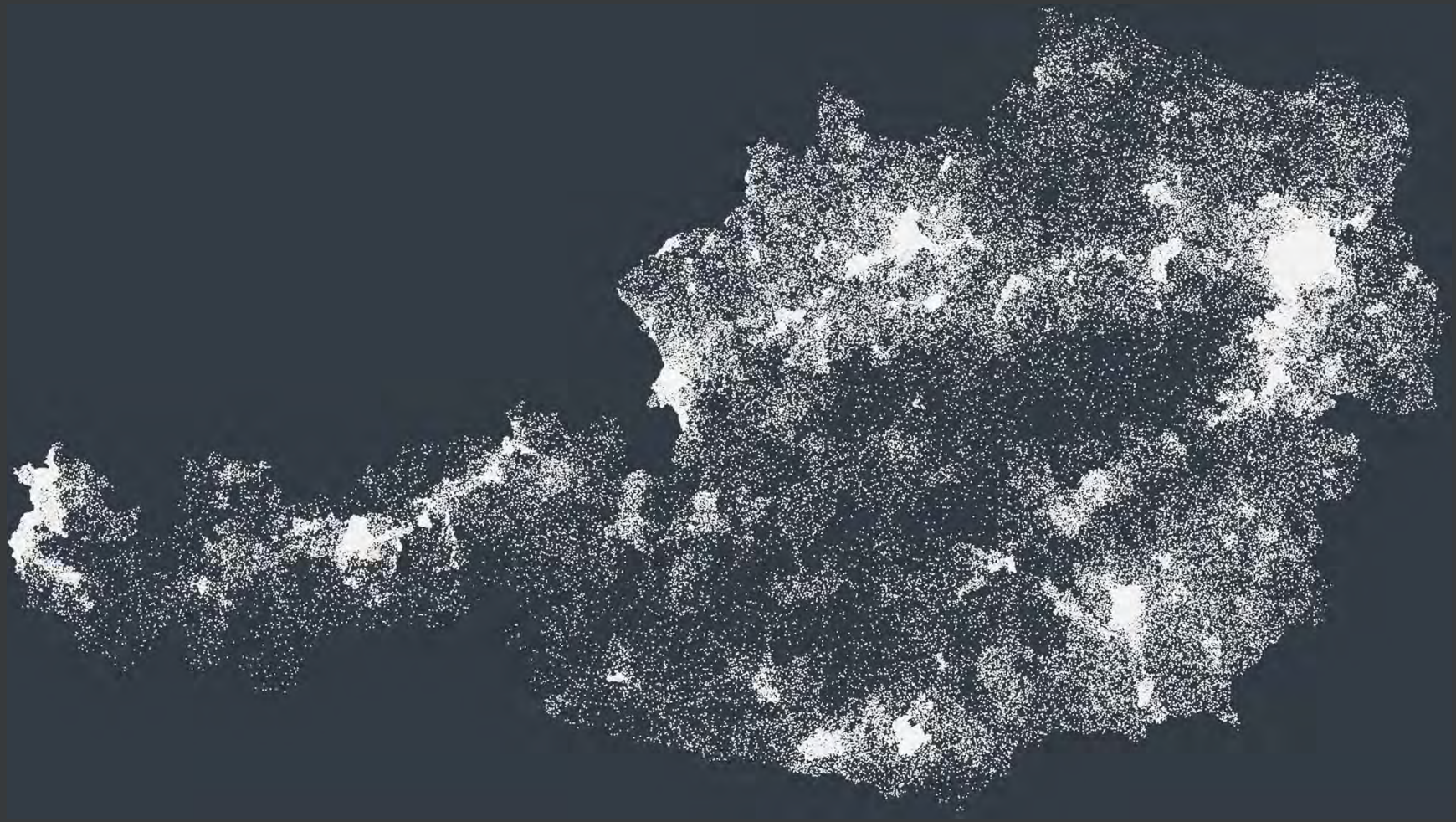
Improvement using the GHS layer



Improvement using the GHS layer

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without

with

Global Human Settlement Index refinement

Vienna

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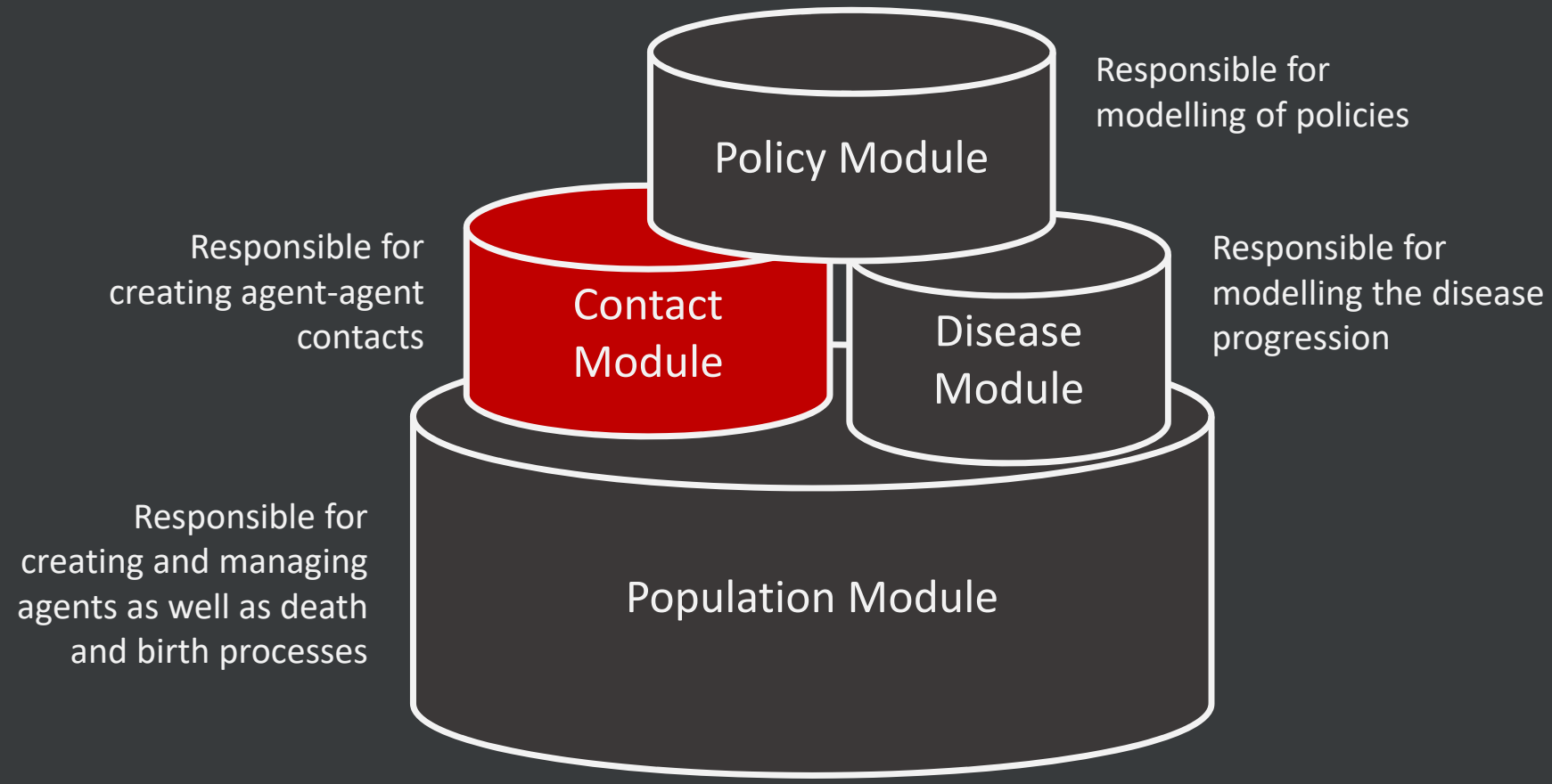
Model Overview



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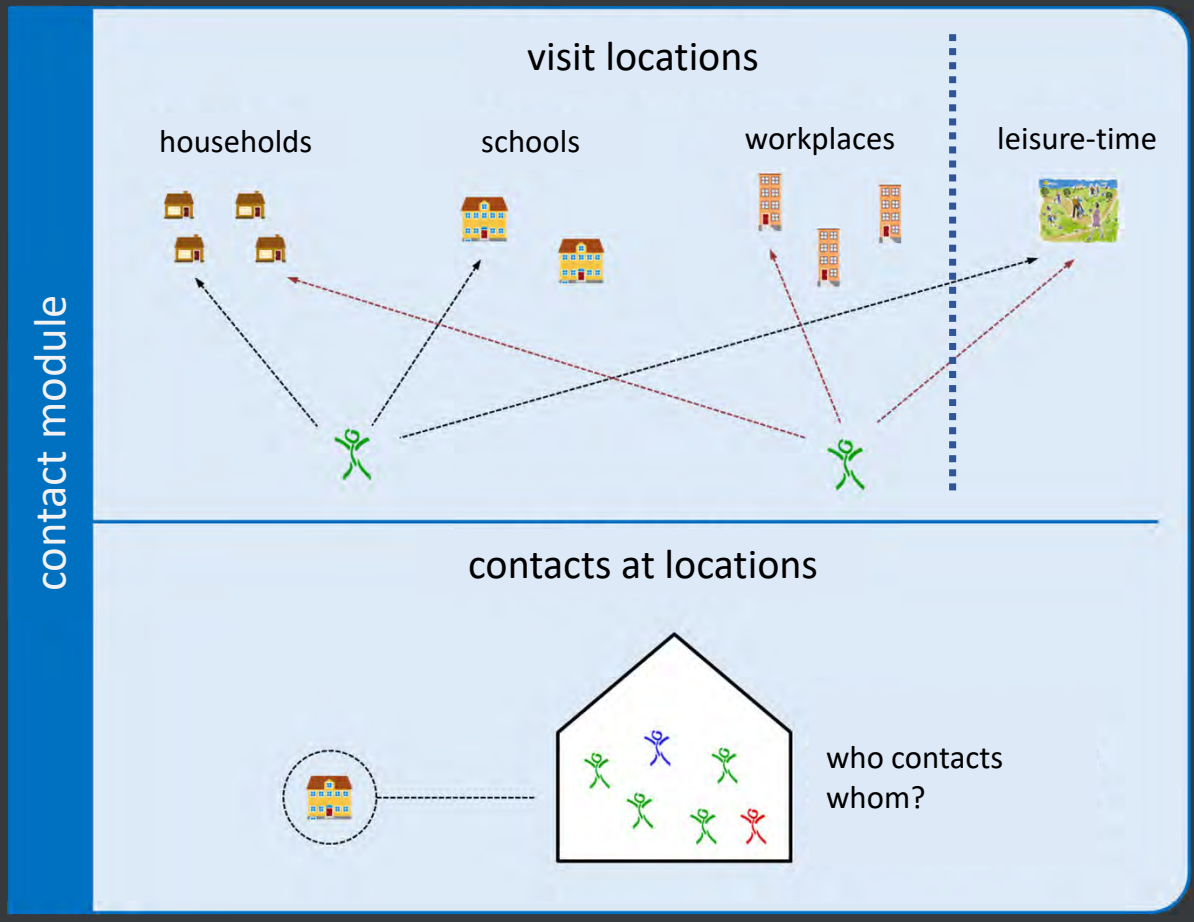
Contact Module – Locations

- Most contacts are not direct but **agent-location-agent** contacts
- Location types: **households, schools, workplaces**
- Additonal **agent-agent** leisure time contacts



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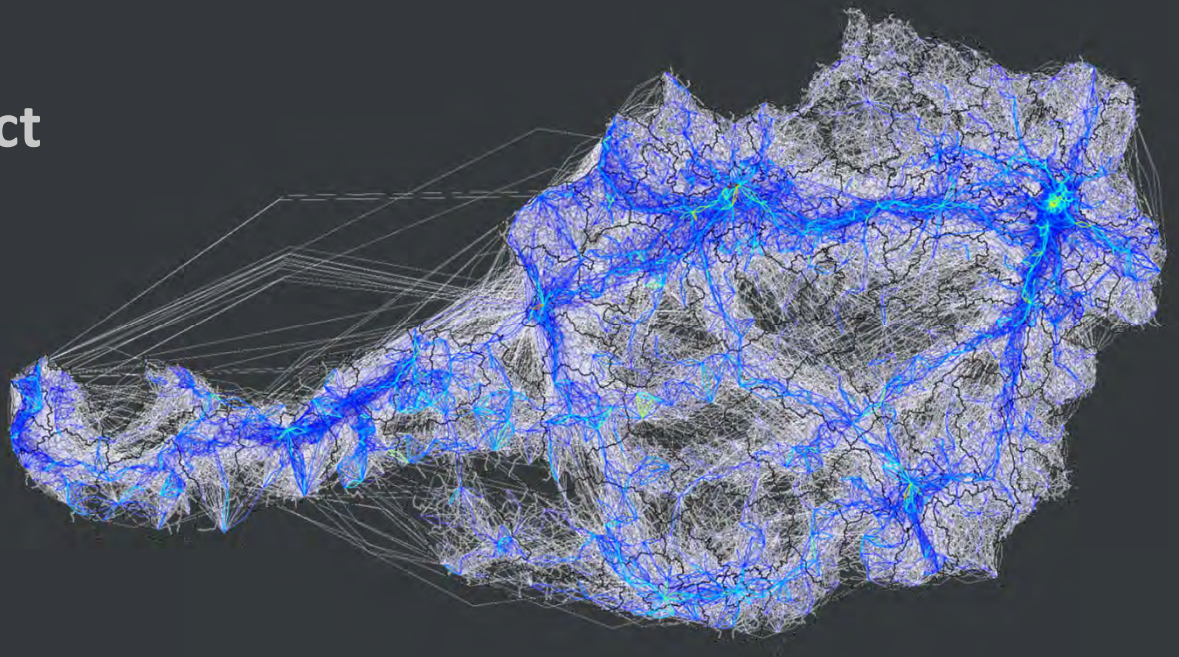
Contact Module – Leisure Time Contacts

- **Assigment of locations** and
- sampling of **leisure time contact partners** is locally biased
- Region specific distribution based on mobile phone data (Origin-Destination Matrix)
- WWTF Project: *Synthese von Krankheitsausbreitungs- und Netzwerksdaten für die Covid-19-Simulation*



Contact Module – Network

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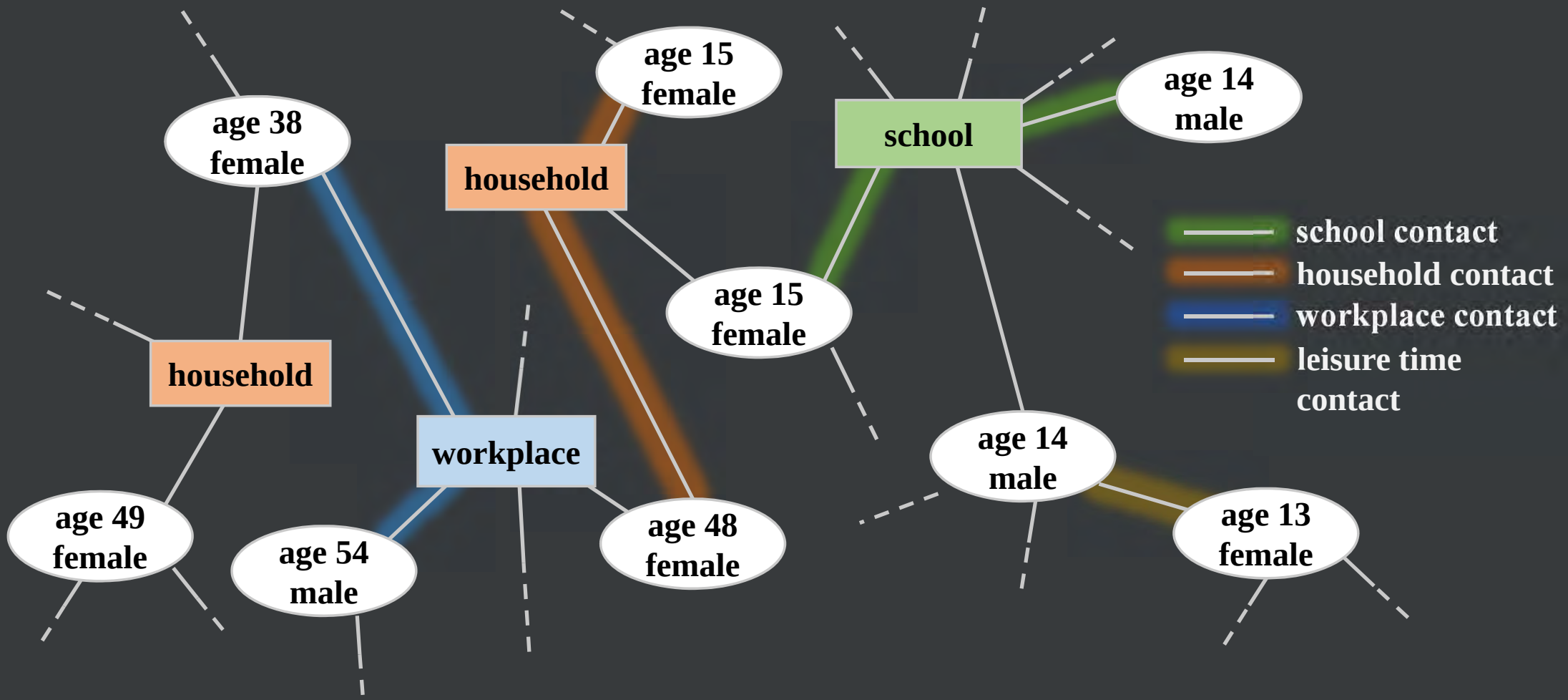

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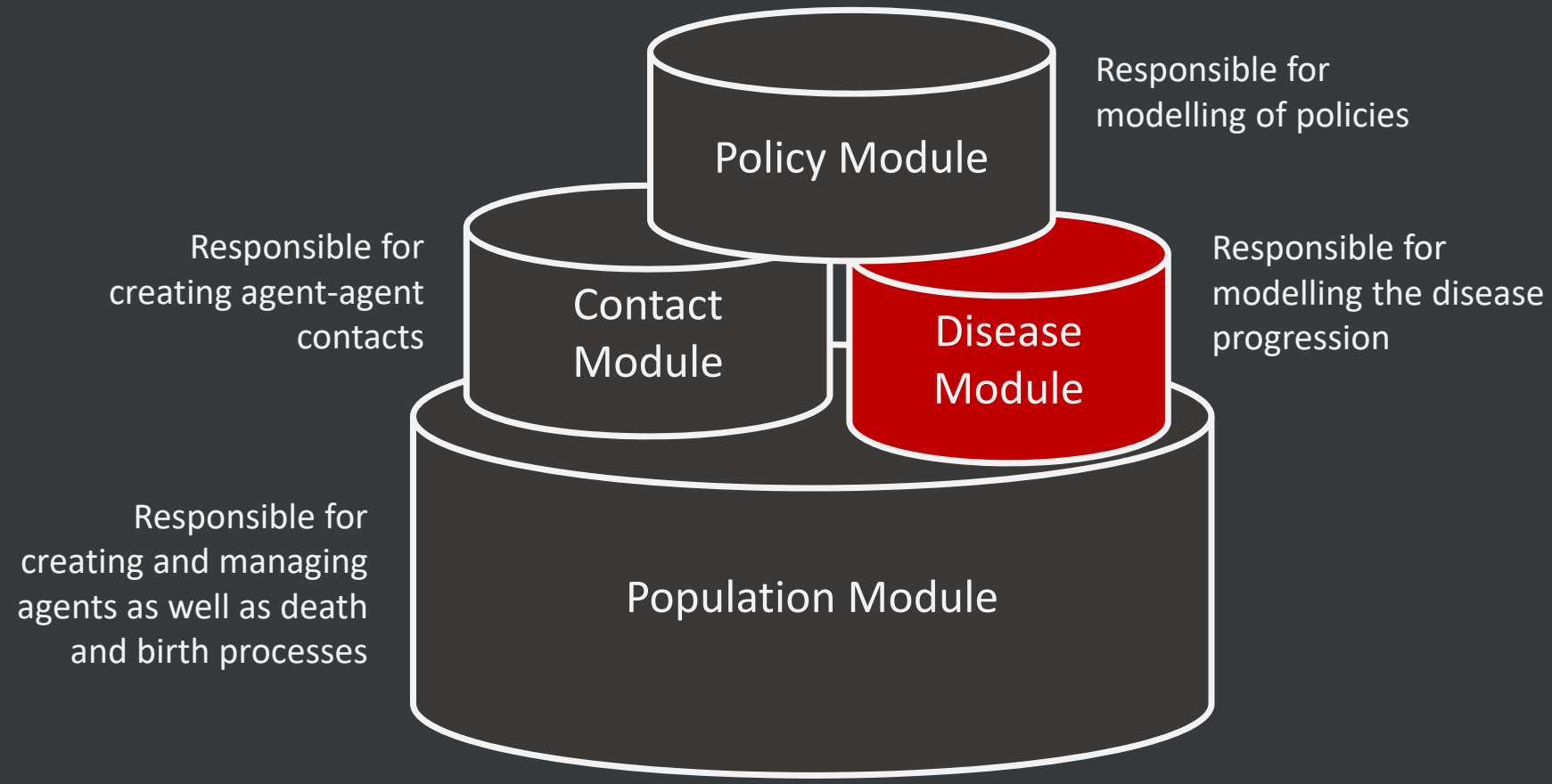
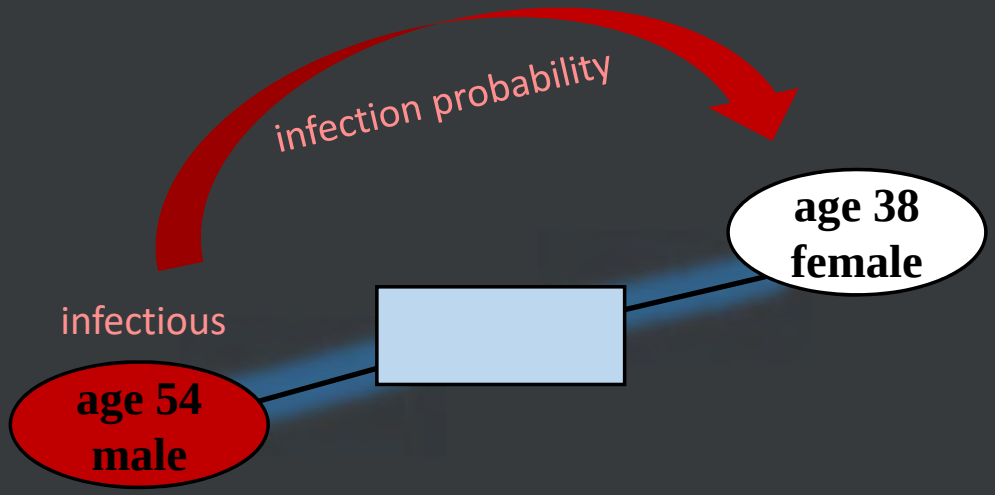
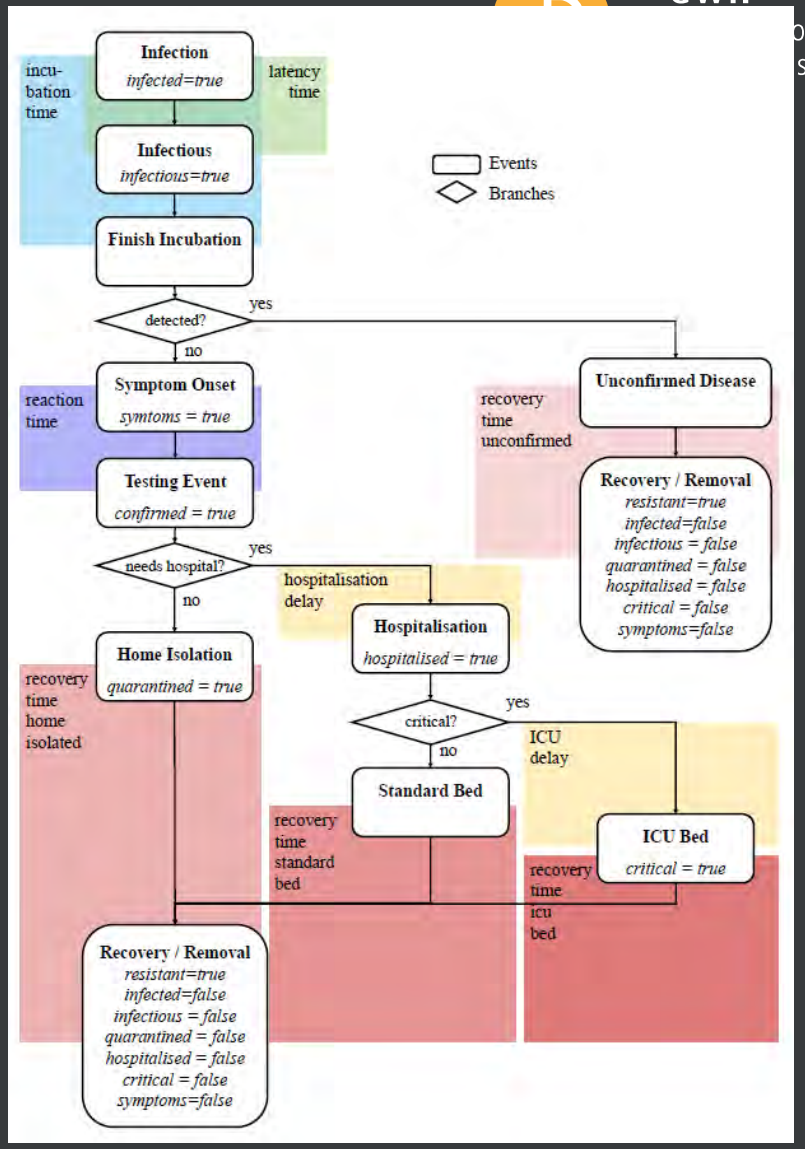


Disease Module

- Disease progression is handled in form of a flow-chart
- Each agent uses is own discrete-event simulator





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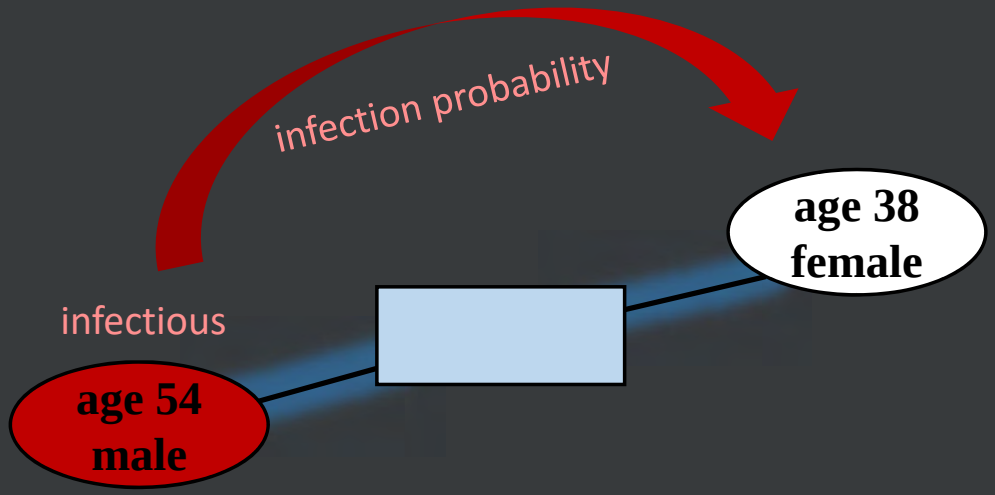

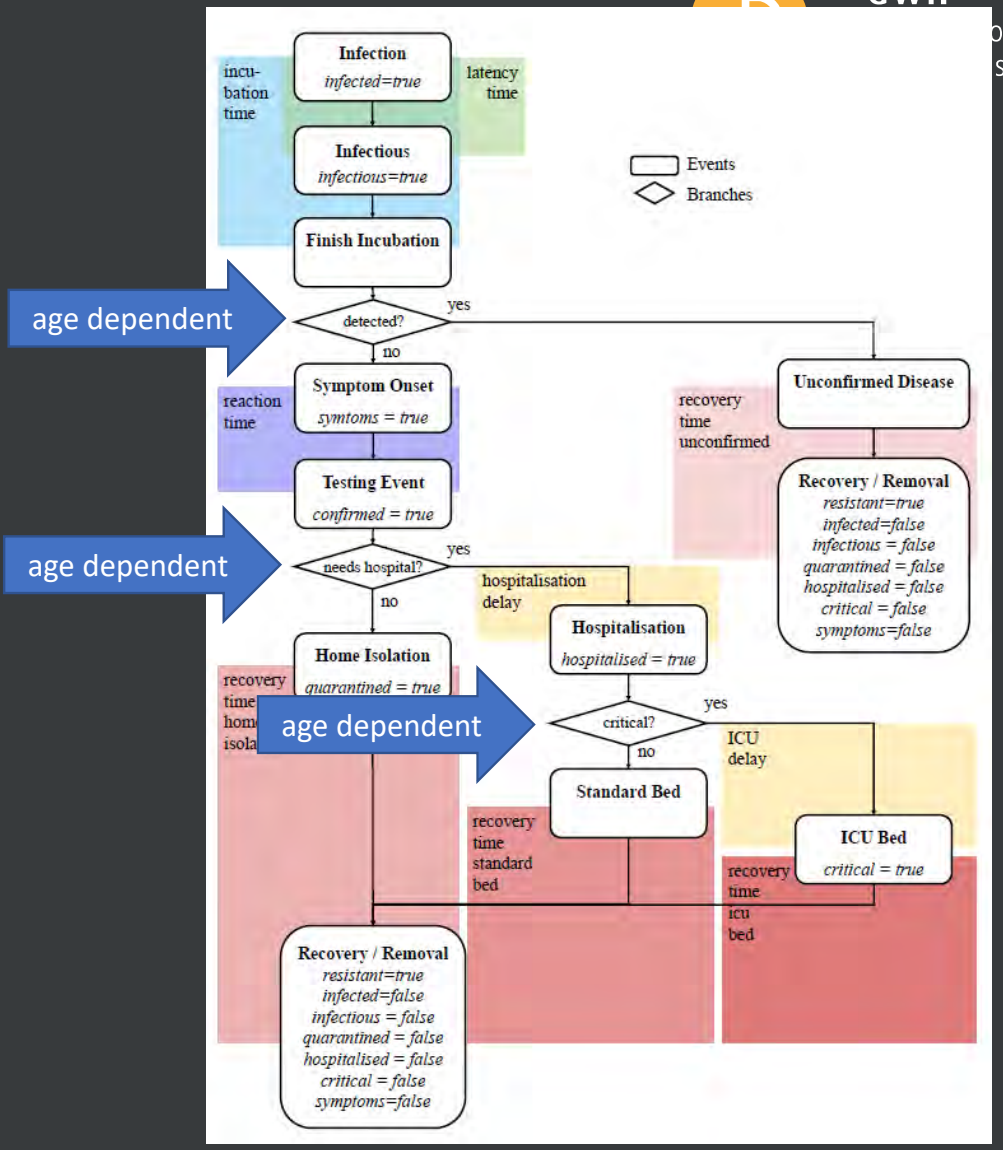

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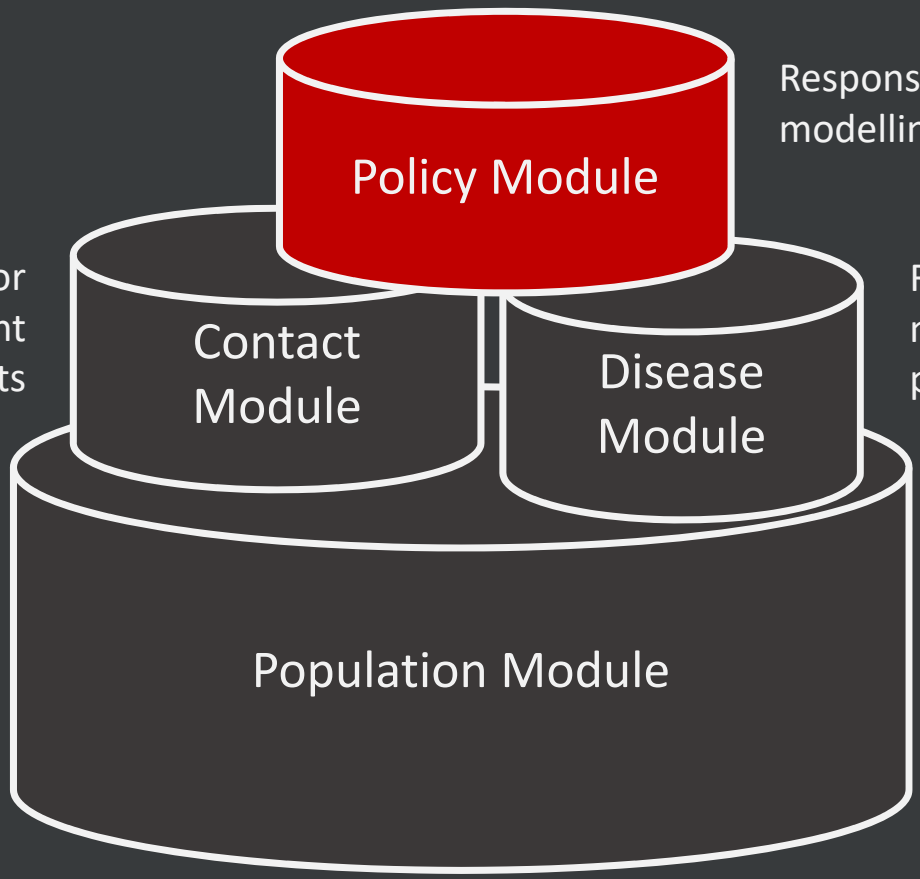
Model Overview



Responsible for modelling of policies

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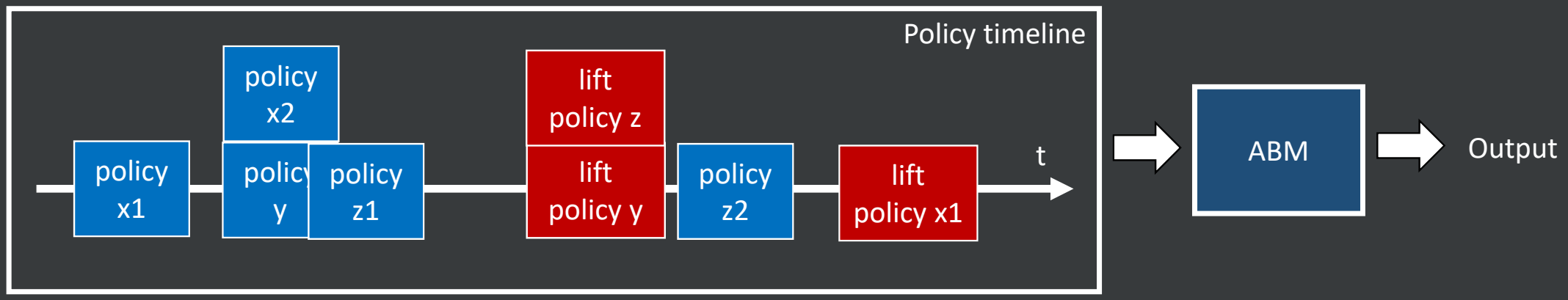
Policy Module – General Concept

- The policy module can be interpreted as a time-line of events that works as the actual model input



Policy Module – General Concept

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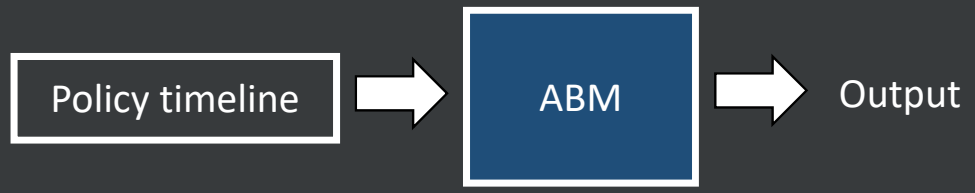
- The policy module can be interpreted as a time-line of events that works as the actual model input
- Examples for Policy Types:
  - **Closing of locations**
  - **Reduction of contacts at sp. locations and/or sp. age classes**
  - **Reduced infectivity at sp. Locations**
  - **Increased awareness (reduced reaction time)**
  - **Location tracing**
  - **Individual tracing**
- All policies can be parametrised



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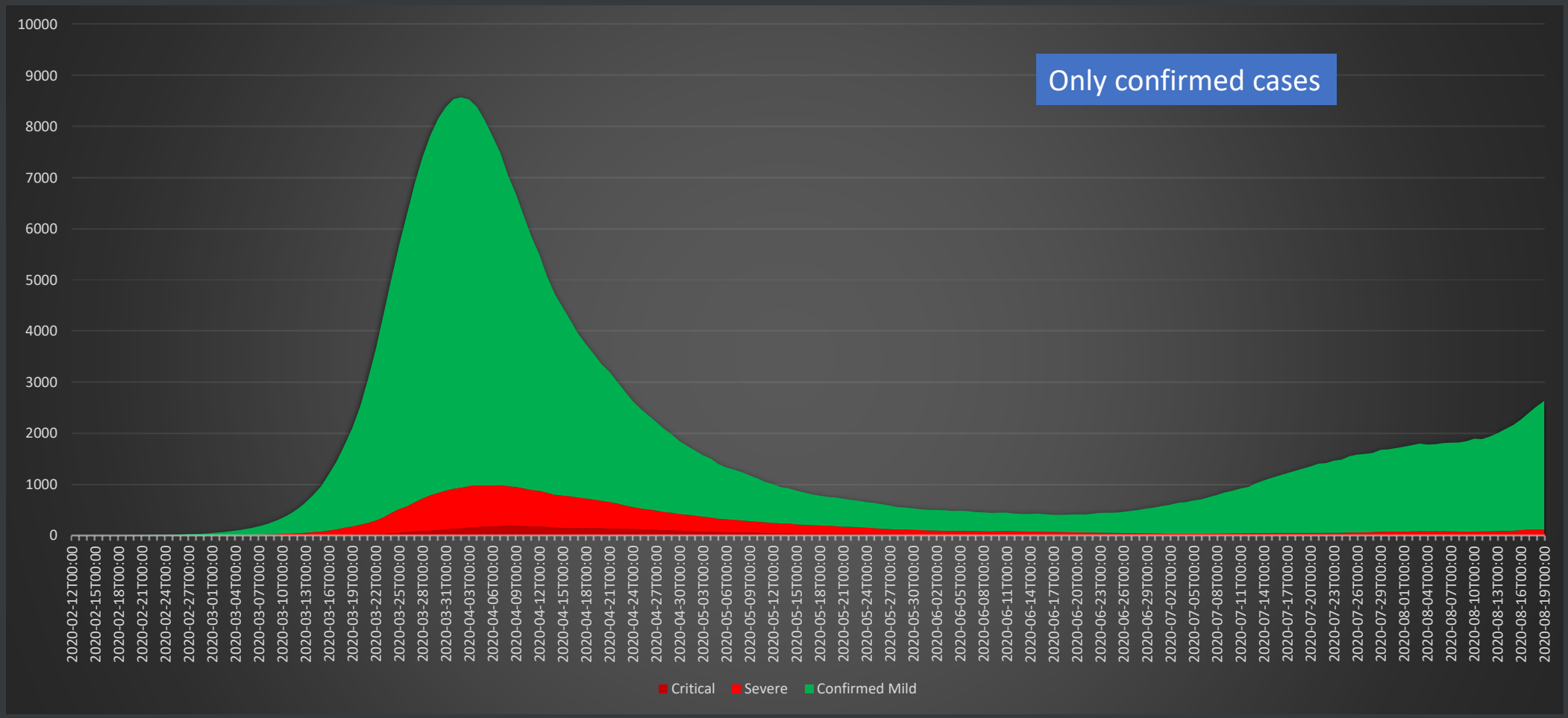
Example: Calibrated Status-Quo



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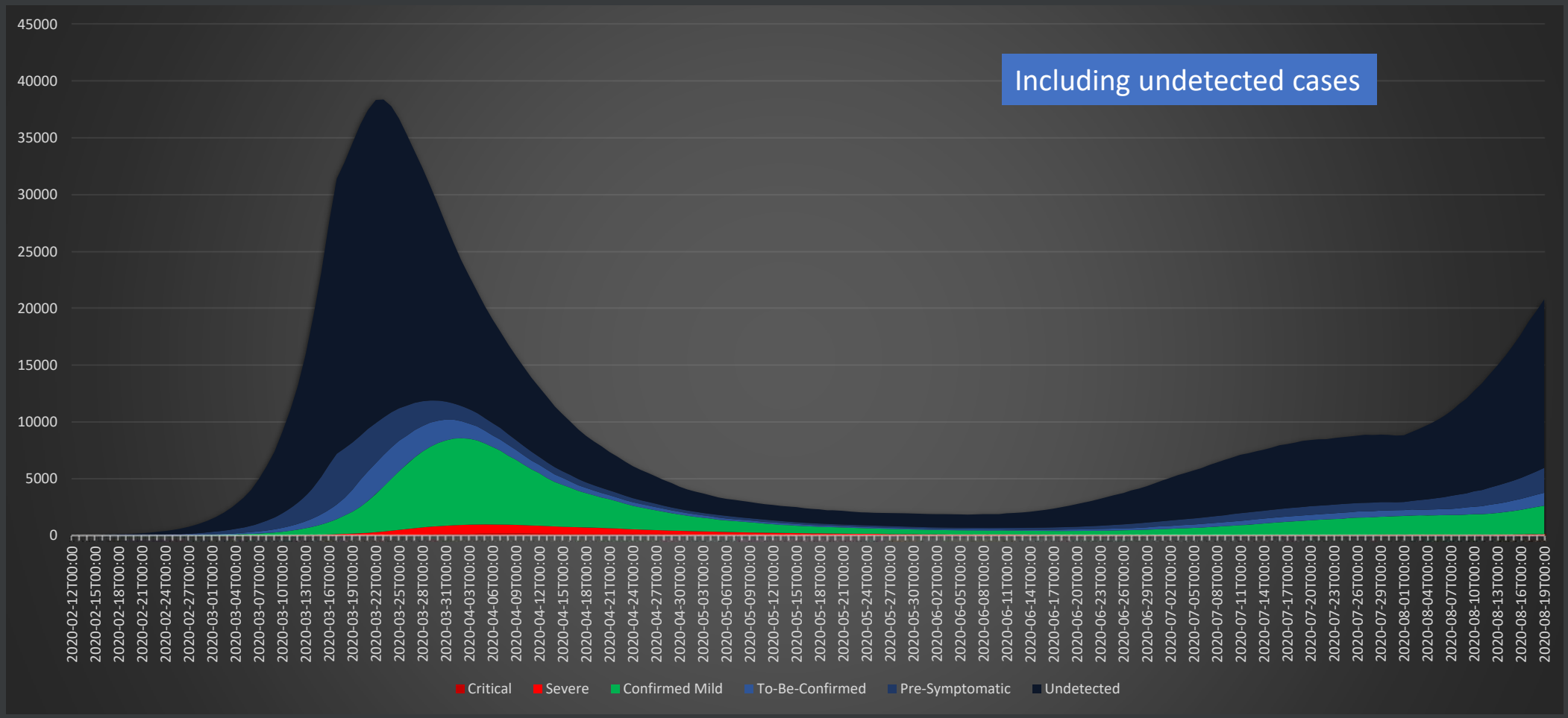

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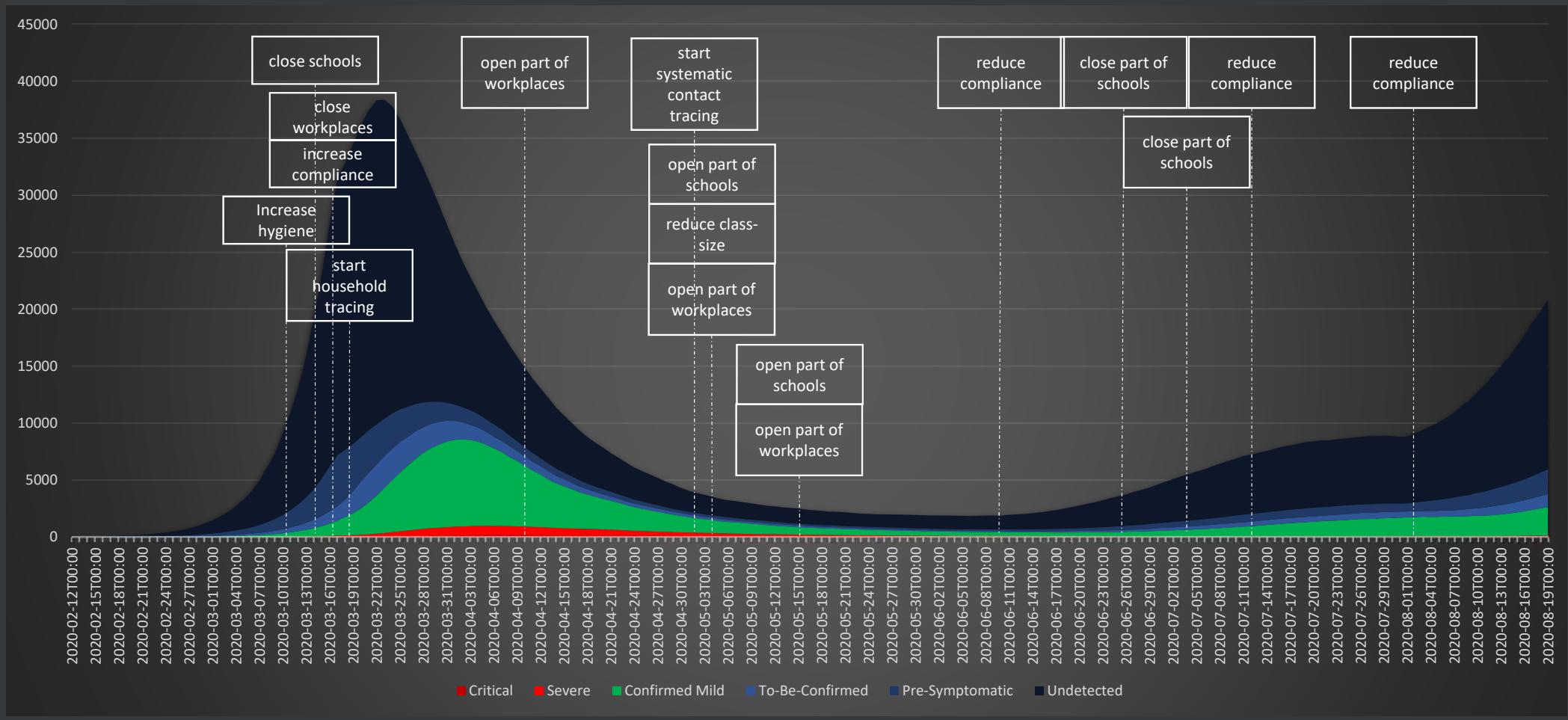

Analysis of Impact of Leisure Time Contacts

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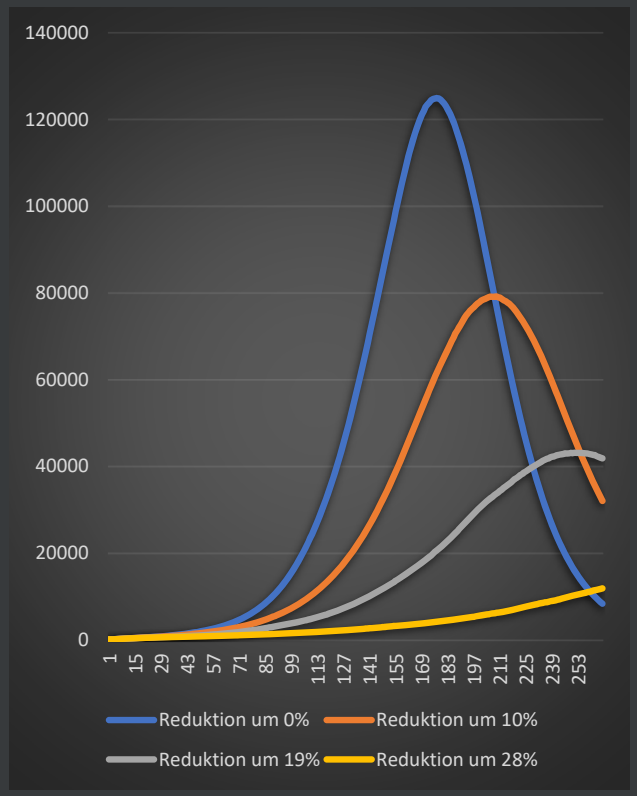

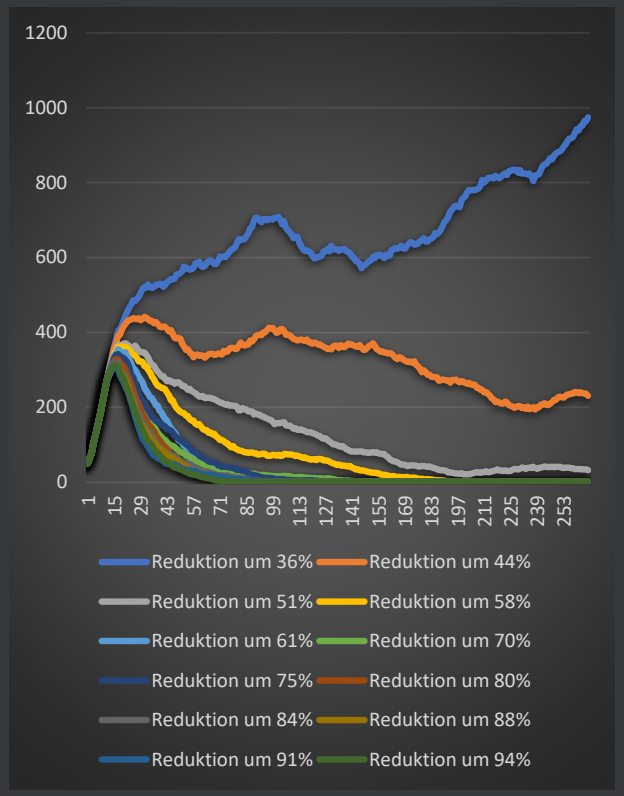

- March 13th-17th
- Analysis on how much, leisure time contacts have to be reduced to cut the epidemic
- Major outcomes:
  - We need to reduce a lot (in addition to other measures)!
  - Even if we manage the early peak, it will take a while, to push the numbers down

Evaluation of Tracing

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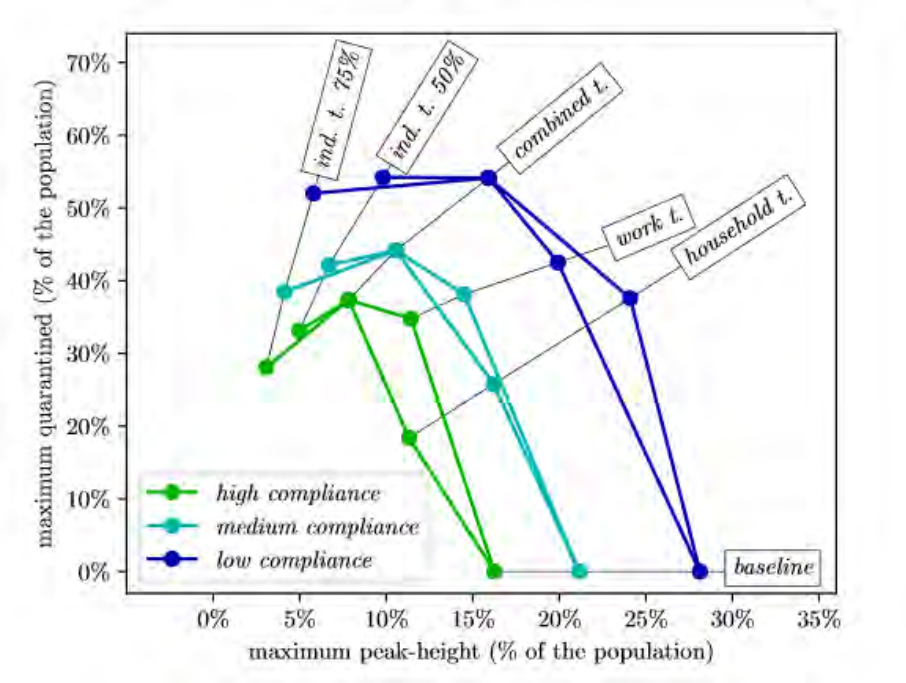

- Mid April
- Analysis on the impact of tracing in different characteristics
- Major outcomes:
  - Tracing is effective if disease is well contained
  - Too many new infections reduce effectiveness and increase efforts for tracing
- Publication under Review.
  Preprint:
  https://www.medrxiv.org/content/10.1101/2020.05.12.20098970v2

Evaluation of Age Distribution

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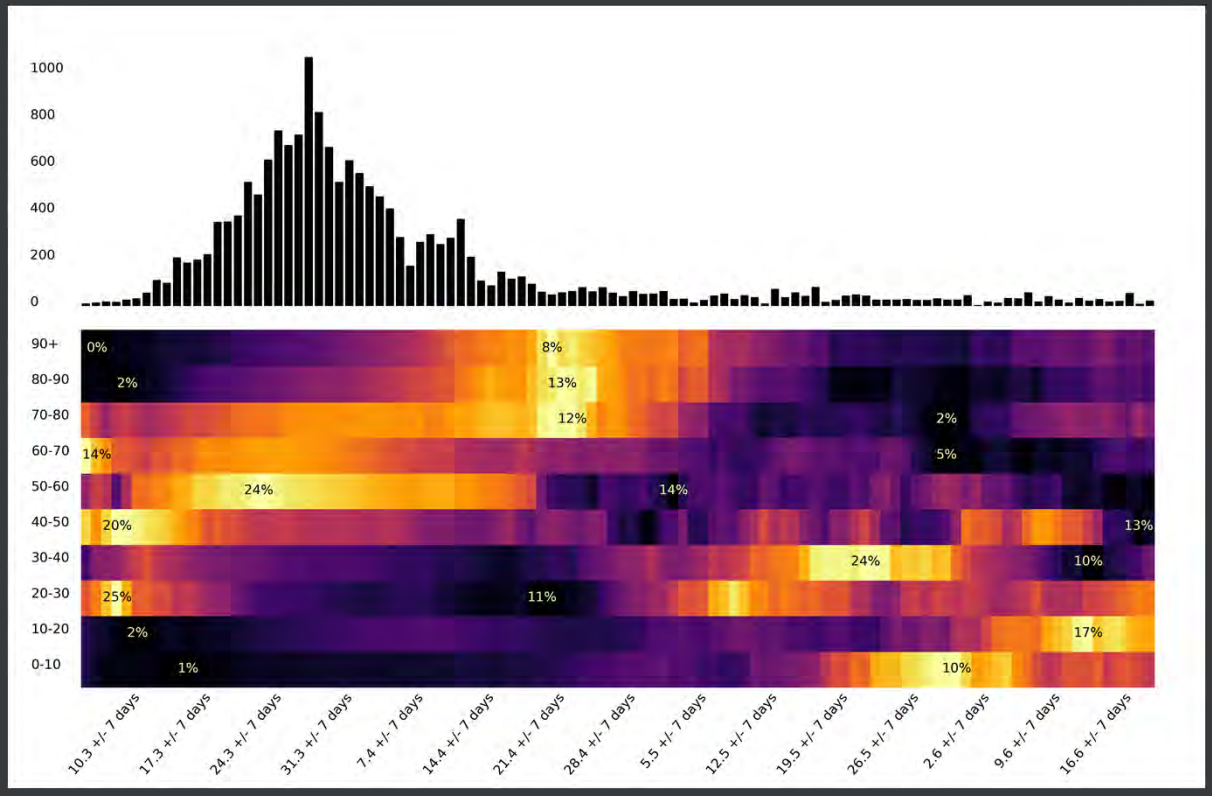

- Recent
- Evaluation of the age-distribution of confirmed cases w.r. to time
- Major outcomes:
  - Elderly are currently well isolated (reduced risk for capacity problems of hospitals)
  - School and work-place opening and screening had a singificant impact

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Simulation as Synthetic Data Source

Synthetic EMS:

- Trace all events:
  - Timestamp
  - Person ID
  - Event type (Changing Infection status, hospital stay,...)
  - Contact ID (if contact event)
  - Contact Type (Work, School, Leisure Time)

	A	B	C	D	E	F	G
1	time	person_id	event_type	contact_id	contact_type		
143	2020-03-13:00:00:00	1899875844	InfectiousContactEvent	566909493	LEISURETIME_CONTACT		
144	2020-03-13:04:35:54	826444777	DeathEvent				
145	2020-03-13:16:00:00	127213061	StartInfectiousEvent				
146	2020-03-13:15:00:00	1945637426	StartSymptomsEvent				

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Simulation as Synthetic Data Source

Simulated Cluster Tramsmission