

H²ABM: Heterogeneous Agent-based Model on Hypergraphs to Capture Group Interactions



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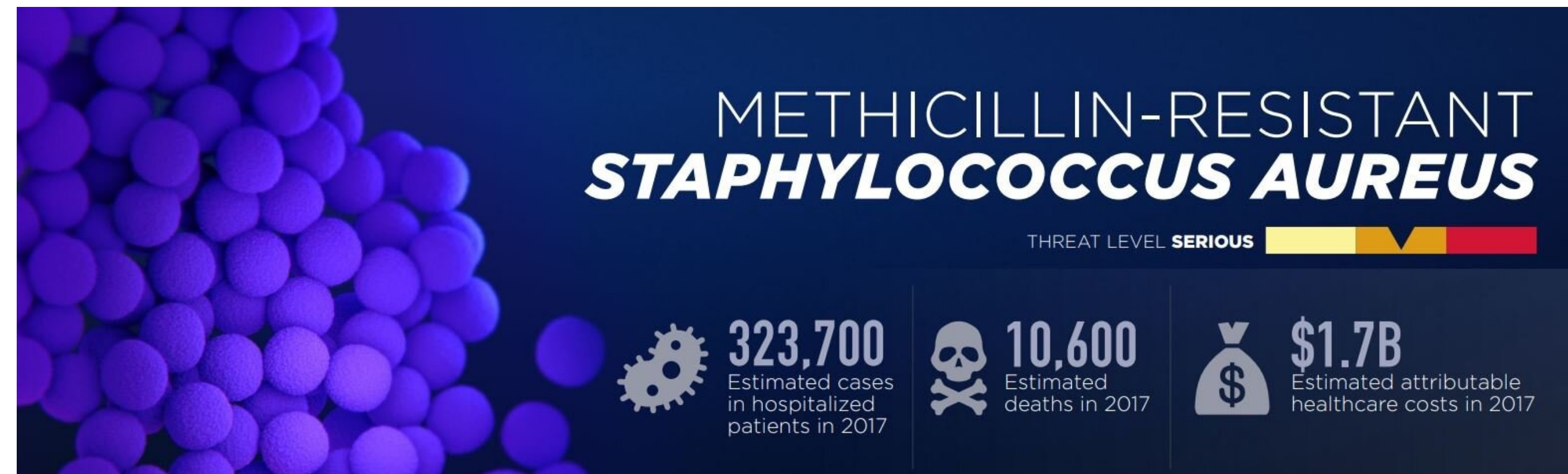
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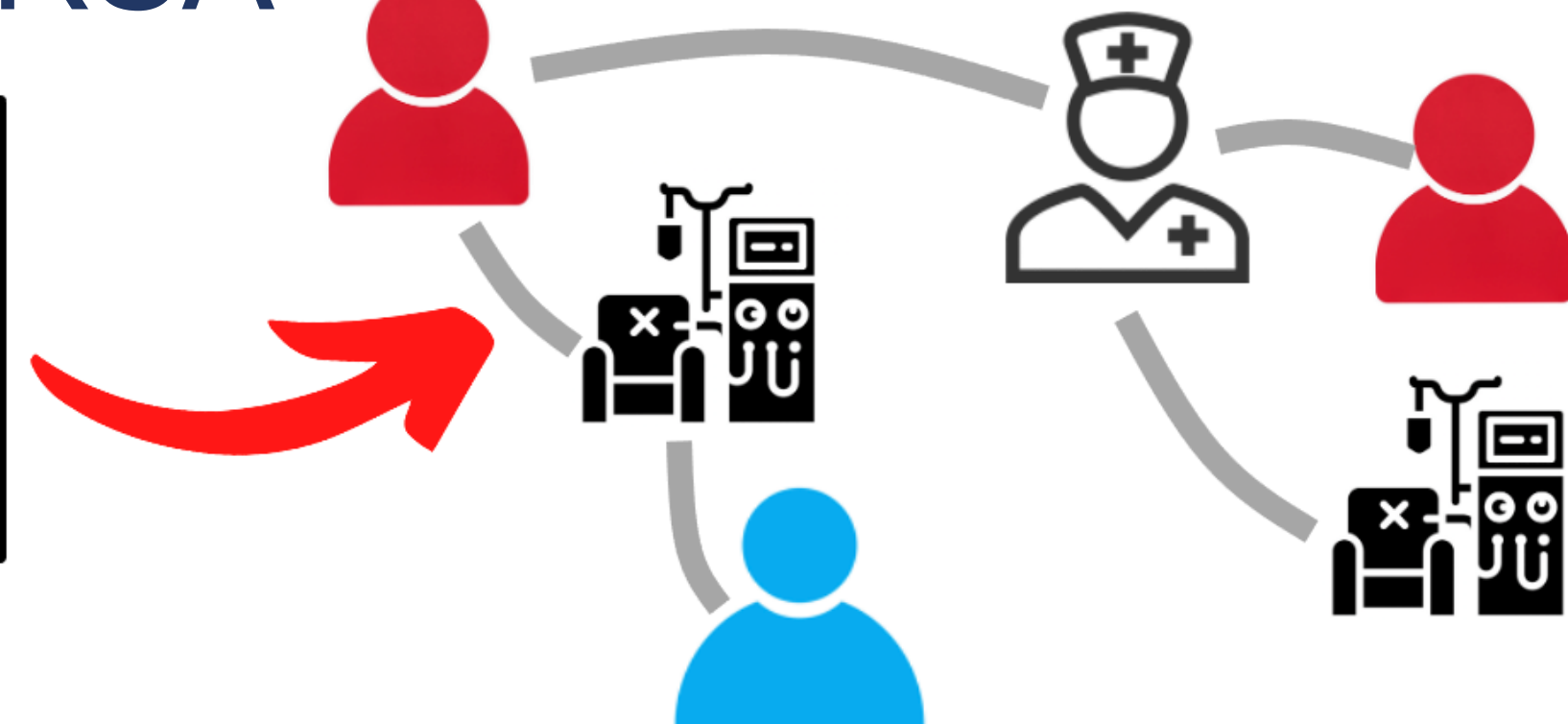
HABM for MRSA

- MRSA: A kind of healthcare associated infections (HAI)
- Severe outcomes

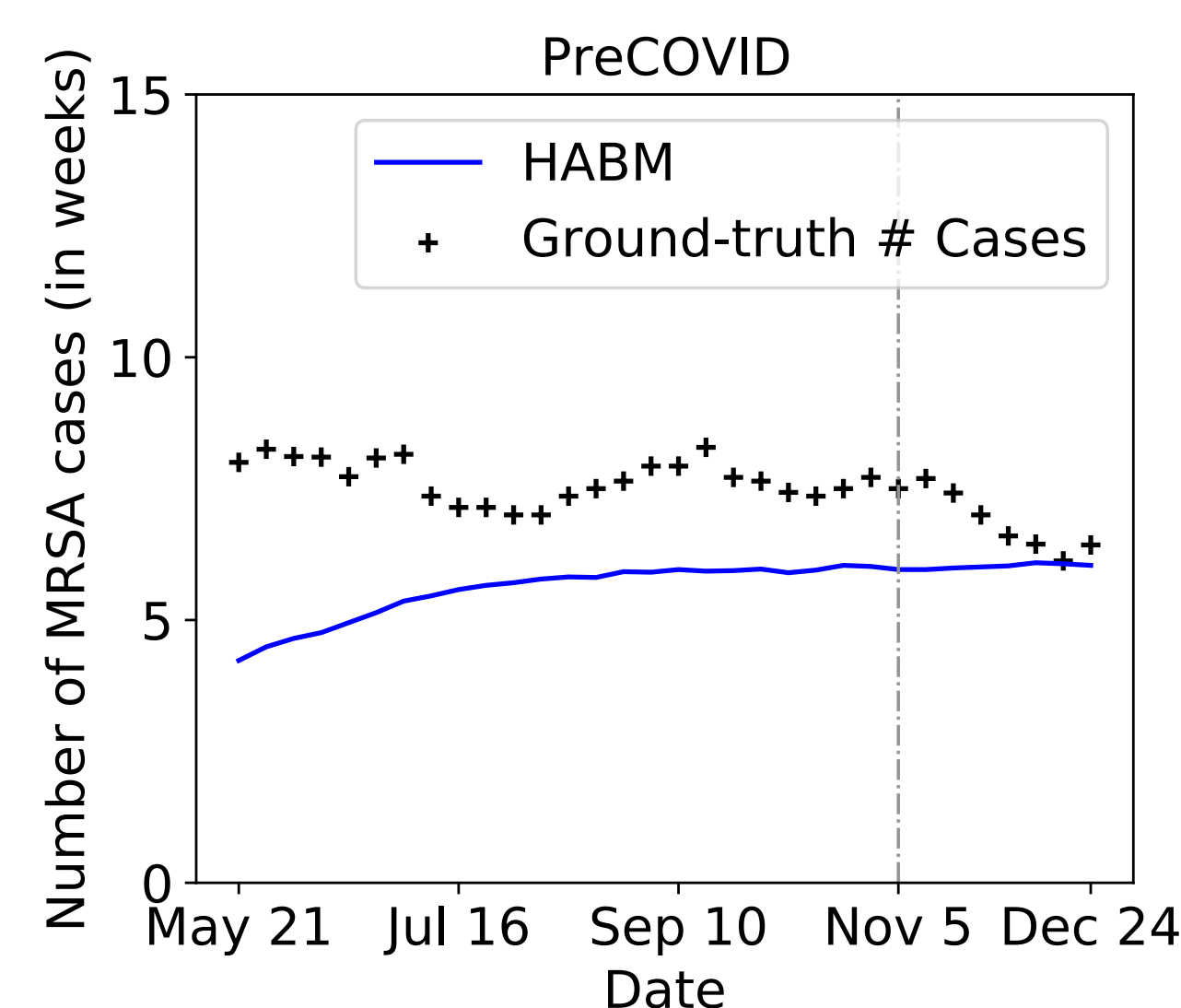


- Heterogeneous agent-based model (HABM) for MRSA^[1]

Trace Data
p₁ is at l₁ from t=0 to t=10
HCW₁ is at l₁ from t=0 to t=5
HCW₁ is at l₂ from t=10 to t=15
p₂ is at l₁ from t=0 to t=5
p₃ is at l₂ from t=10 to t=20



- HABM also widely applied in other fields
 - Personalized recommendations
 - Publication ranking
- Issue: Not fitting & forecasting well



- Why? Cannot capture **group interactions**

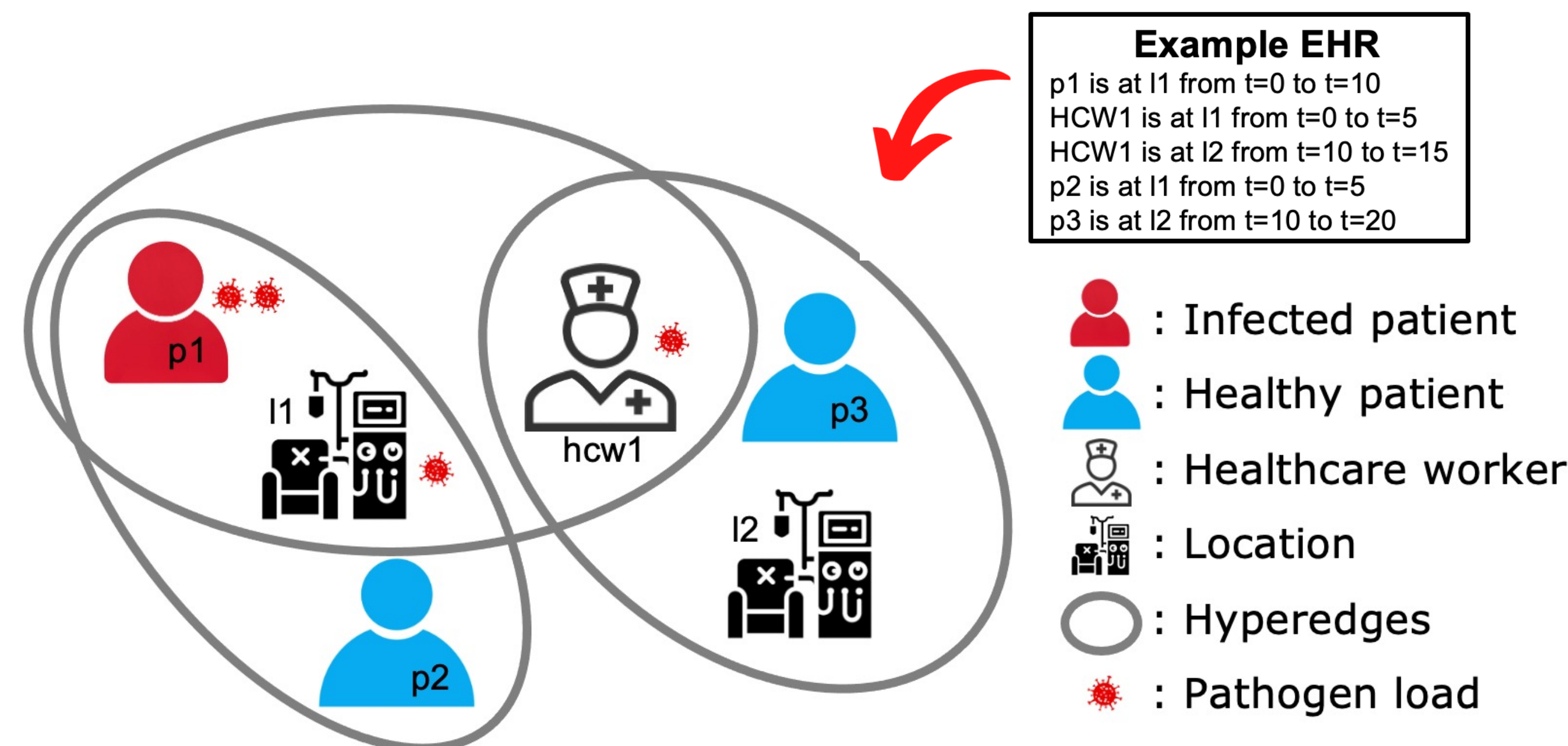
Our idea

- H**ypergraph-based **H**eterogeneous **ABM** (H²ABM)
- We use MRSA spread in UVA hospital as an example



H²ABM for MRSA: Design

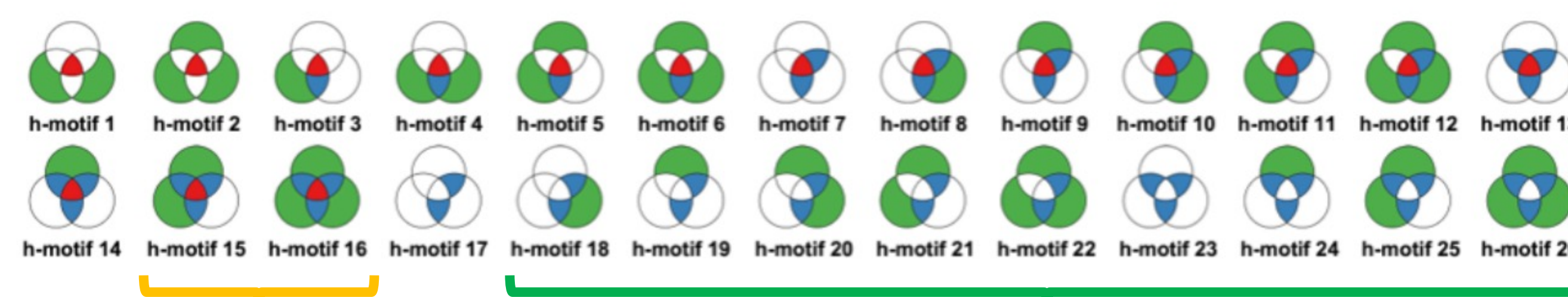
- Hypergraph: Construct hypergraphs using Electronic Health Records (EHR)



- Heterogeneous:
 - Each entity carries some pathogen
 - Pathogen can spread via hyperedges
 - Patient infected probability proportional to pathogen

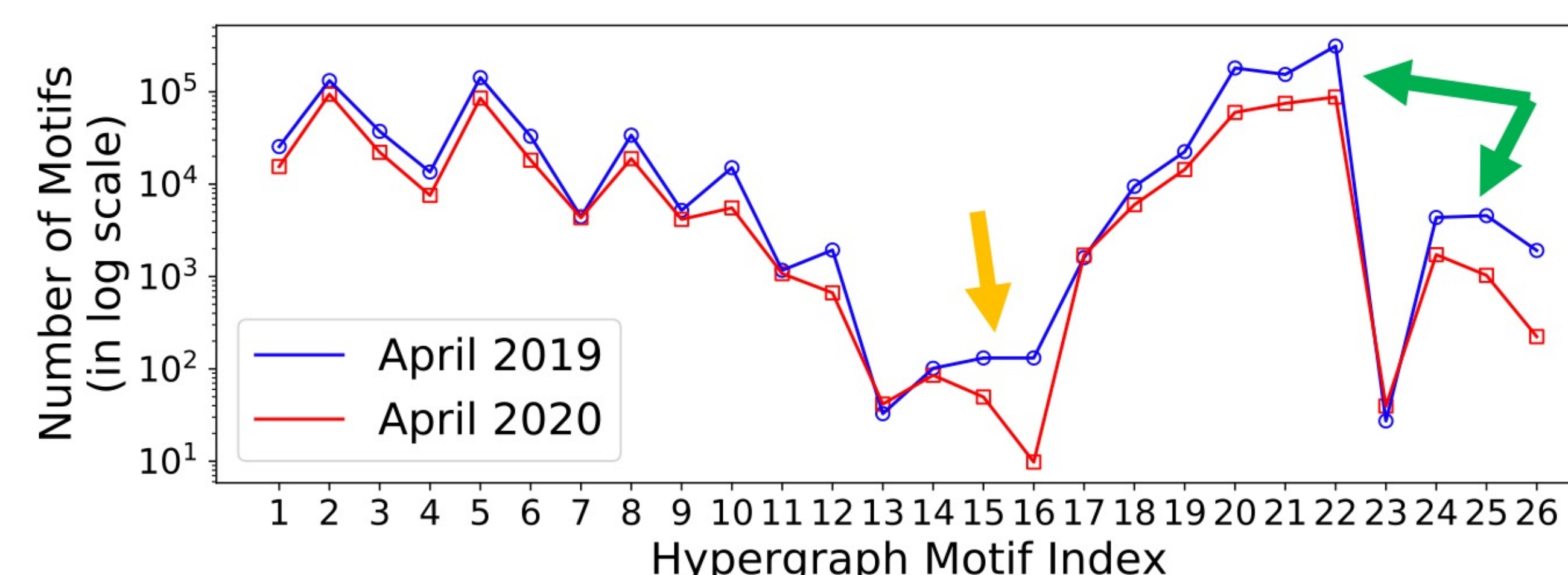
Capturing structural differences

- Comparison: April 2019 vs. April 2020
- Use motifs^[2] to capture differences



Motifs corresponding to group interactions Motifs corresponding to indirect interactions

- April 2020: First wave of COVID-19



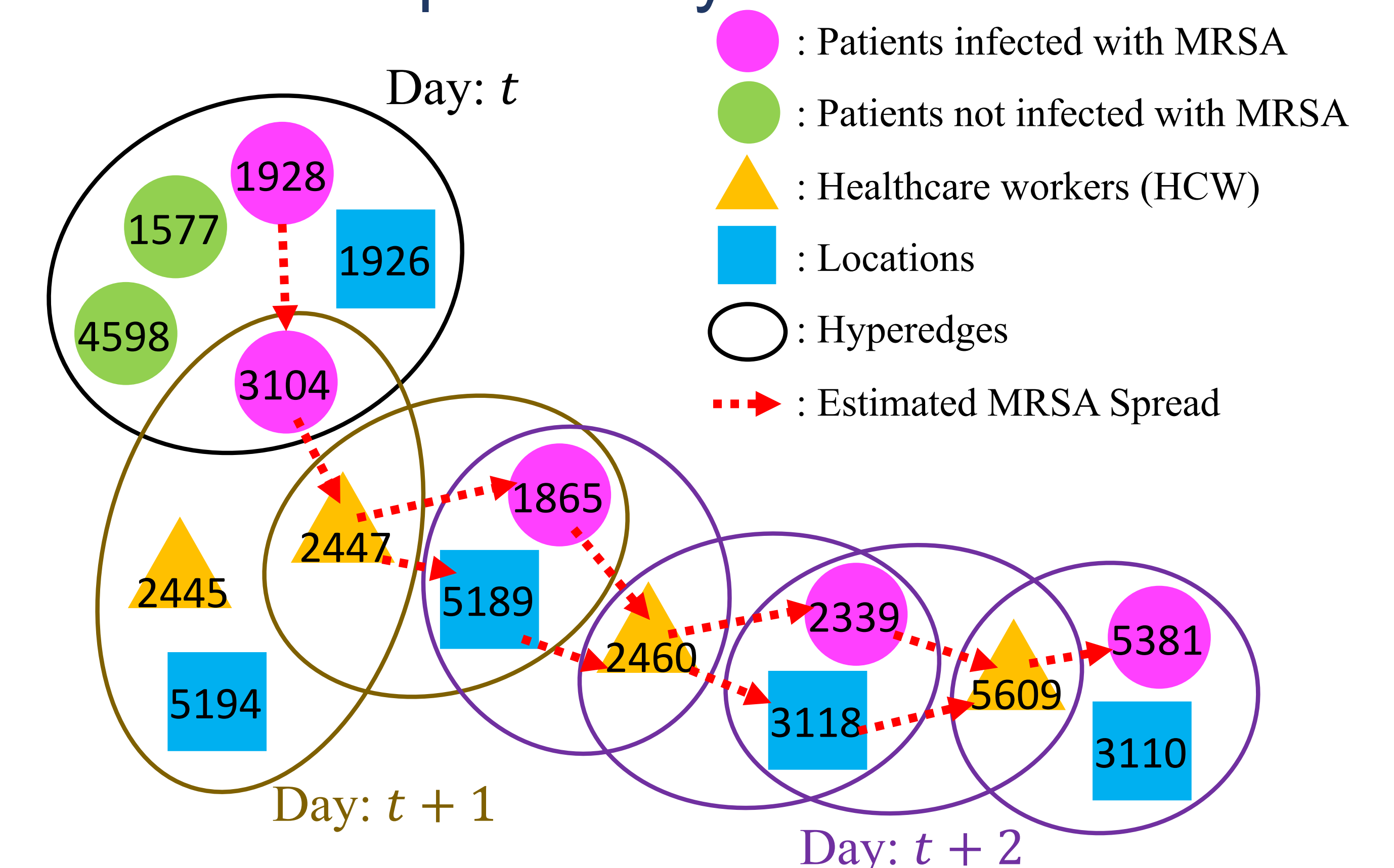
Results

- Better fit in the number of cases

Model	Calibration Performance					
	UVA-PRECOVID			UVA-COVID		
	NRMSE	ND	Pearson correlation	NRMSE	ND	Pearson correlation
HYPERGRAPH-HETERSIS	0.1319	0.1159	0.4294	0.1644	0.1494	0.3304
GRAPH-HETERSIS	0.2512	0.2427	-0.1093	0.3863	0.3380	-0.4381

Model	Forecasting Performance					
	UVA-PRECOVID			UVA-COVID		
	NRMSE	ND	Pearson correlation	NRMSE	ND	Pearson correlation
HYPERGRAPH-HETERSIS	0.1262	0.1091	0.2660	0.1213	0.1061	-0.1793
GRAPH-HETERSIS	0.4215	0.3983	0.1228	0.4733	0.3910	-0.5355

- Better interpretability



Discussions and Conclusions

- We extend HABM to hypergraphs
- Hypergraphs capture the group interactions better than graphs
- H²ABM leads to better interpretability, fitting and forecasting than HABM

Acknowledgements & Contact us



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[1] Cui et al. Using Spectral Characterization to Identify Healthcare-associated Infection (HAI) Patients for Clinical Contact Precaution. Scientific Reports 2023.

[2] Lee et al. Mining of Real-world Hypergraphs: Patterns, Tools, and Generators. KDD 2023.