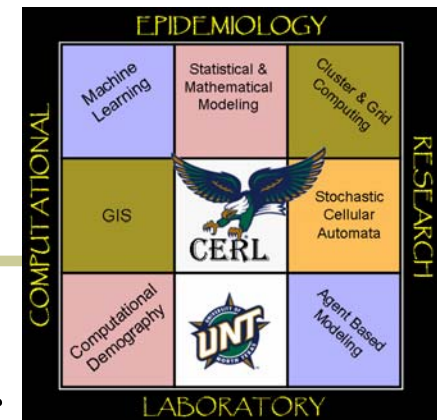


Computational Epidemiology: Bayesian Disease Surveillance

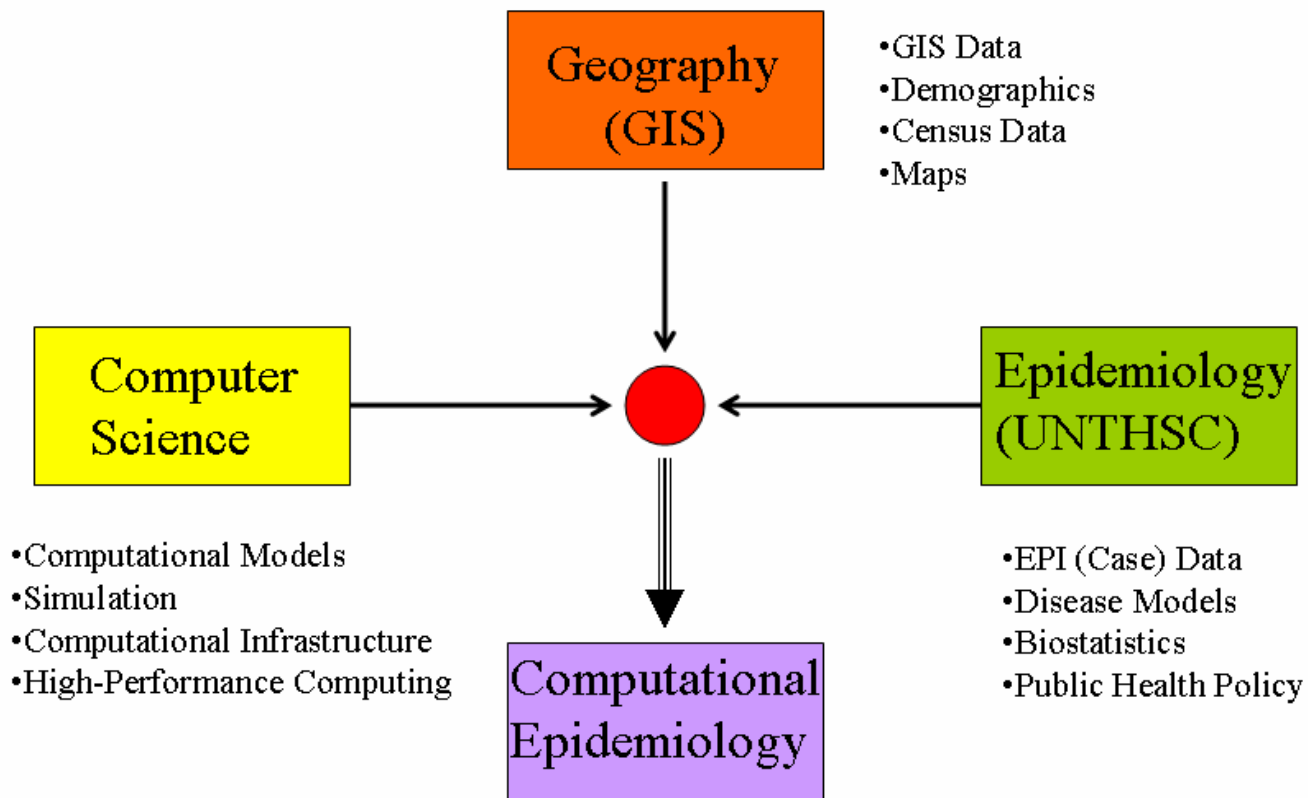
Kaja Abbas, Armin R. Mikler,
Amir Ramezani, Sheena Menezes
University of North Texas



Presentation Outline

- Computational epidemiology
- Brief overview of past epidemics
- Mathematical epidemiological models
- Bayesian learning
- Bayesian disease outbreak model
- Results and analysis
- Conclusion and future work

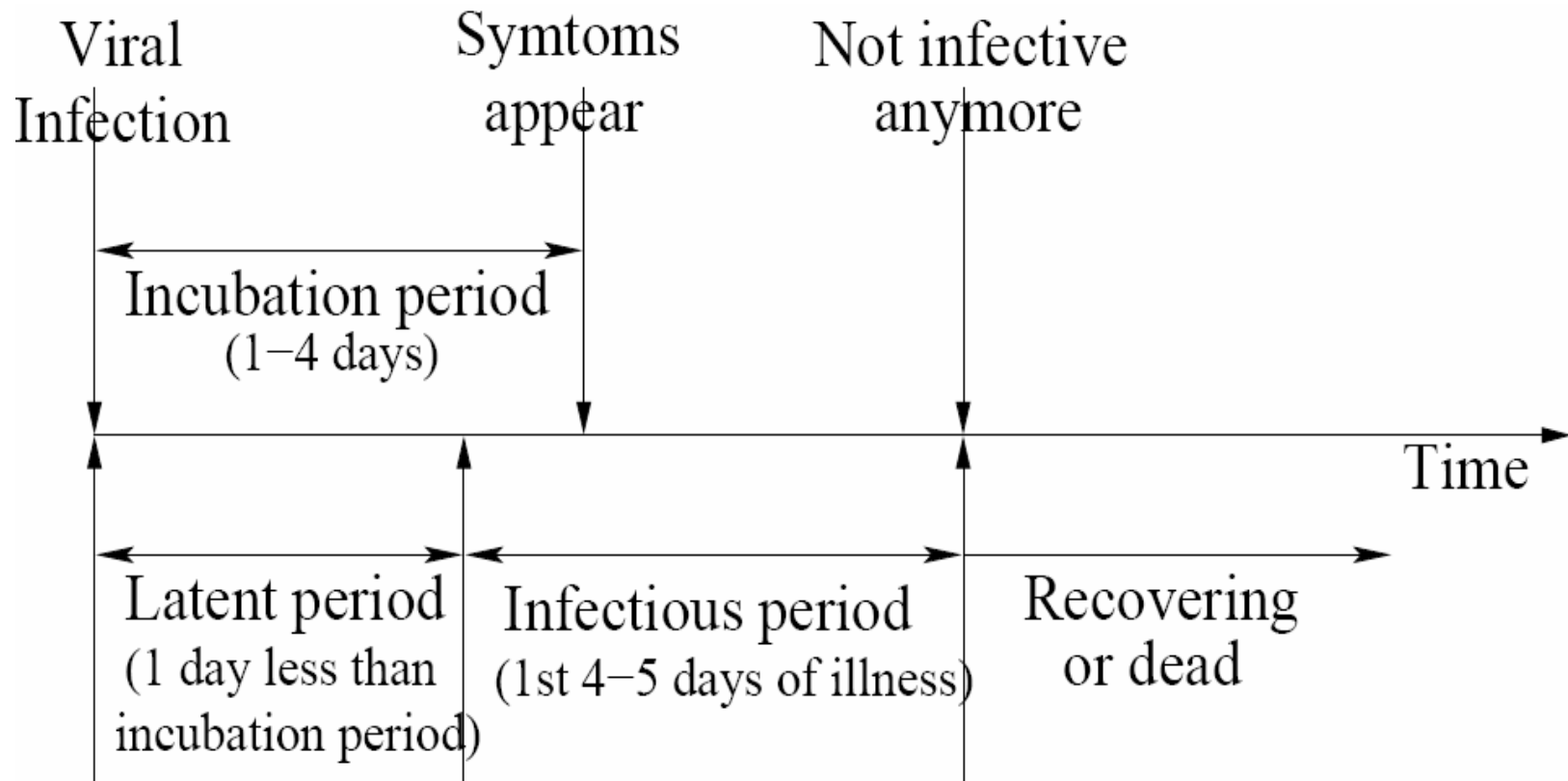
Computational Epidemiology



Epidemic History

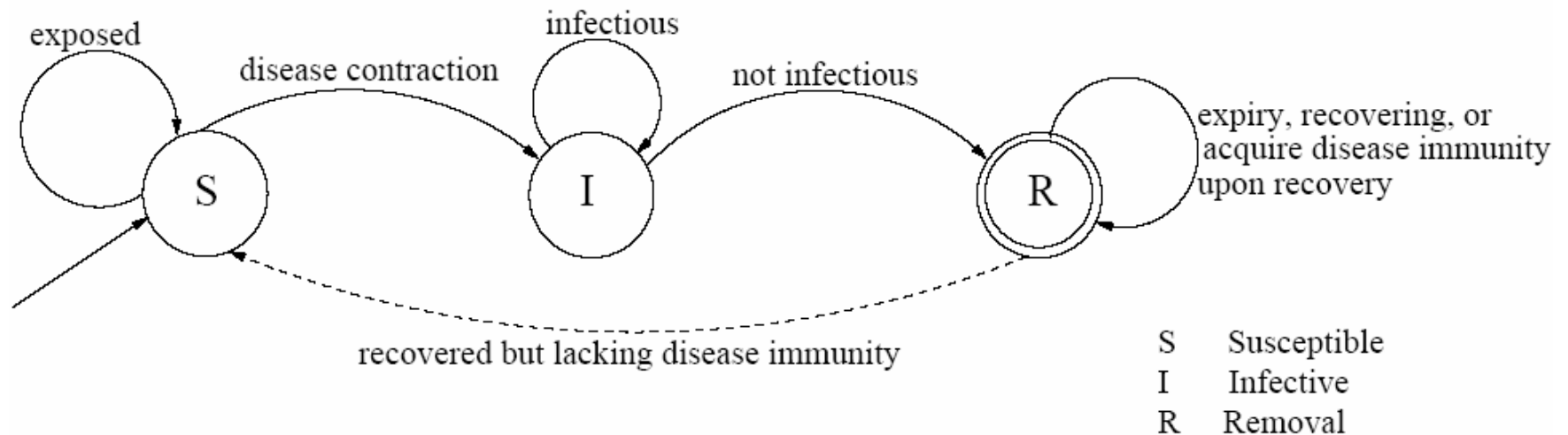
- 14th century: Europe: 25 million: Plague
- 1521: Aztecs: 3.5 million: Small pox
- 1918: Worldwide: at-least 20 million: Influenza
- 2003: SARS: *rapid global spread*

Influenza Infection Timeline



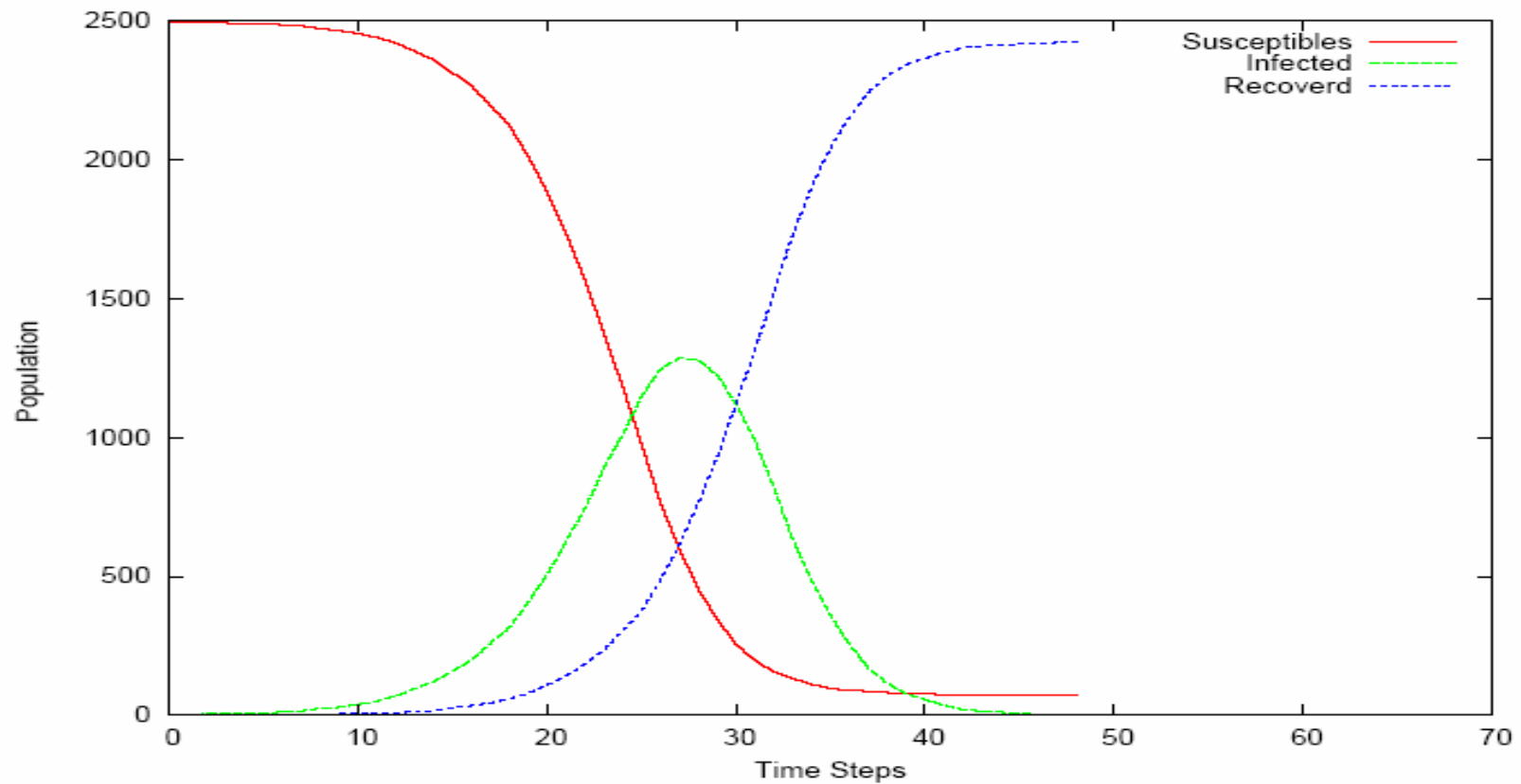
Mathematical Epidemiology

Susceptibles Infectives Removals (SIR) model



SIR State Diagram

SIR Epidemic Curve



Disease Prevalence

Limitations of SIR model

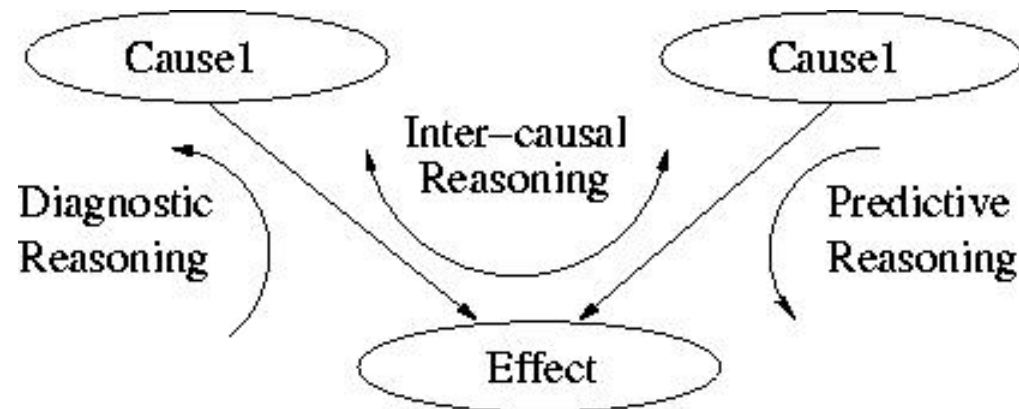
- Explicit representation of outbreak data
- Lack of demographic analysis

Bayesian Epidemic Model

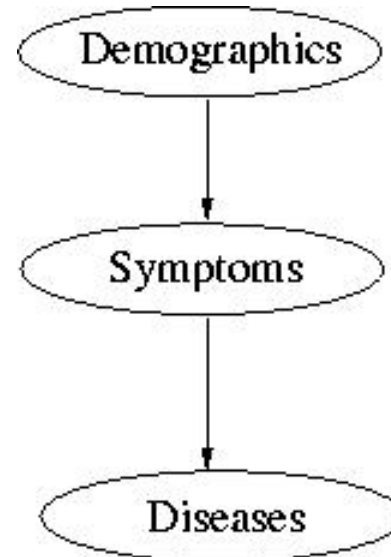
- Learning
- Implicit representation of population demographics

Bayesian Learning

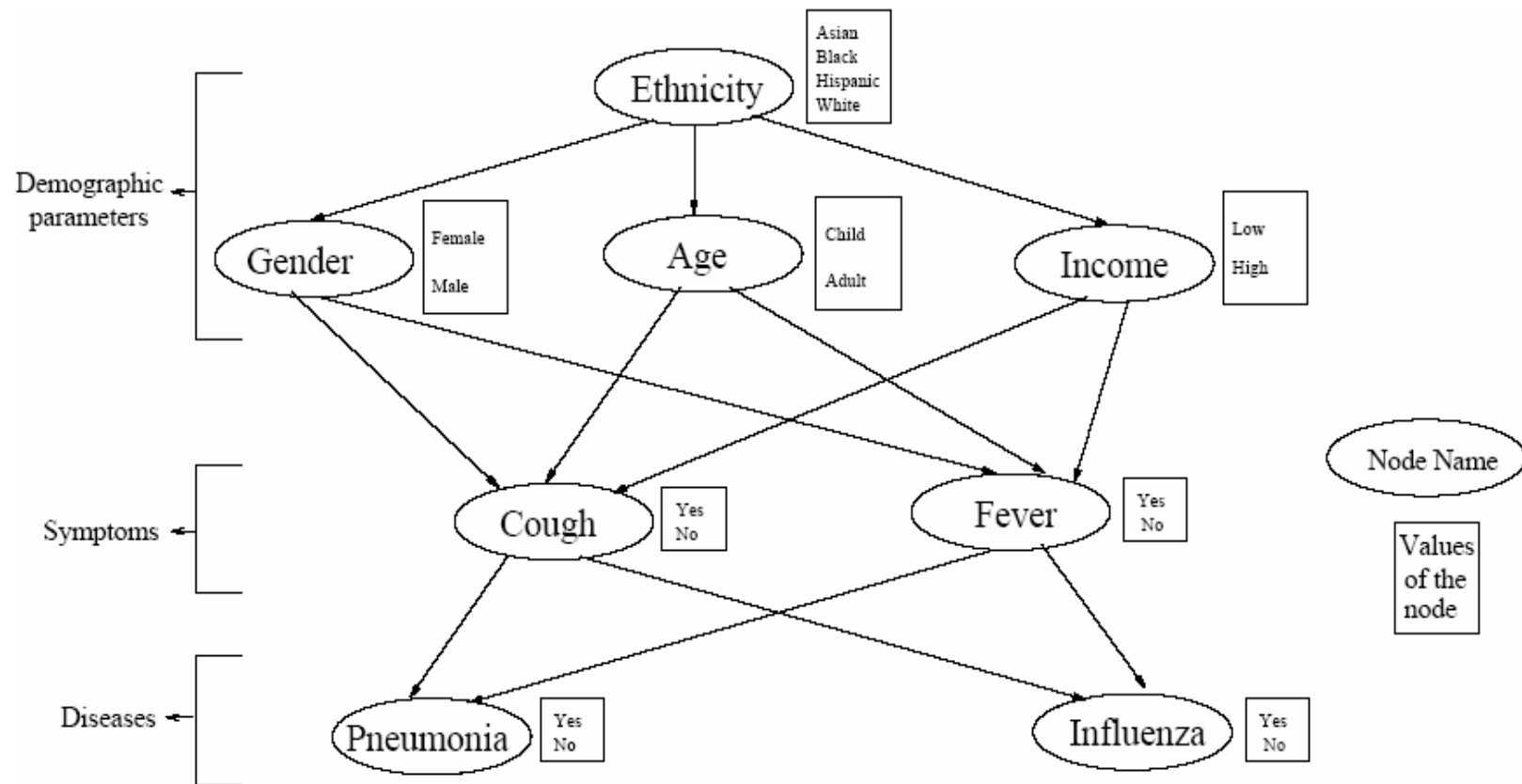
- Probabilistic Reasoning
- Reasoning under uncertainty



Disease Outbreak Bayesian Network



Bayesian Network for Demographic Analysis



Geographic Region I: Probability distributions

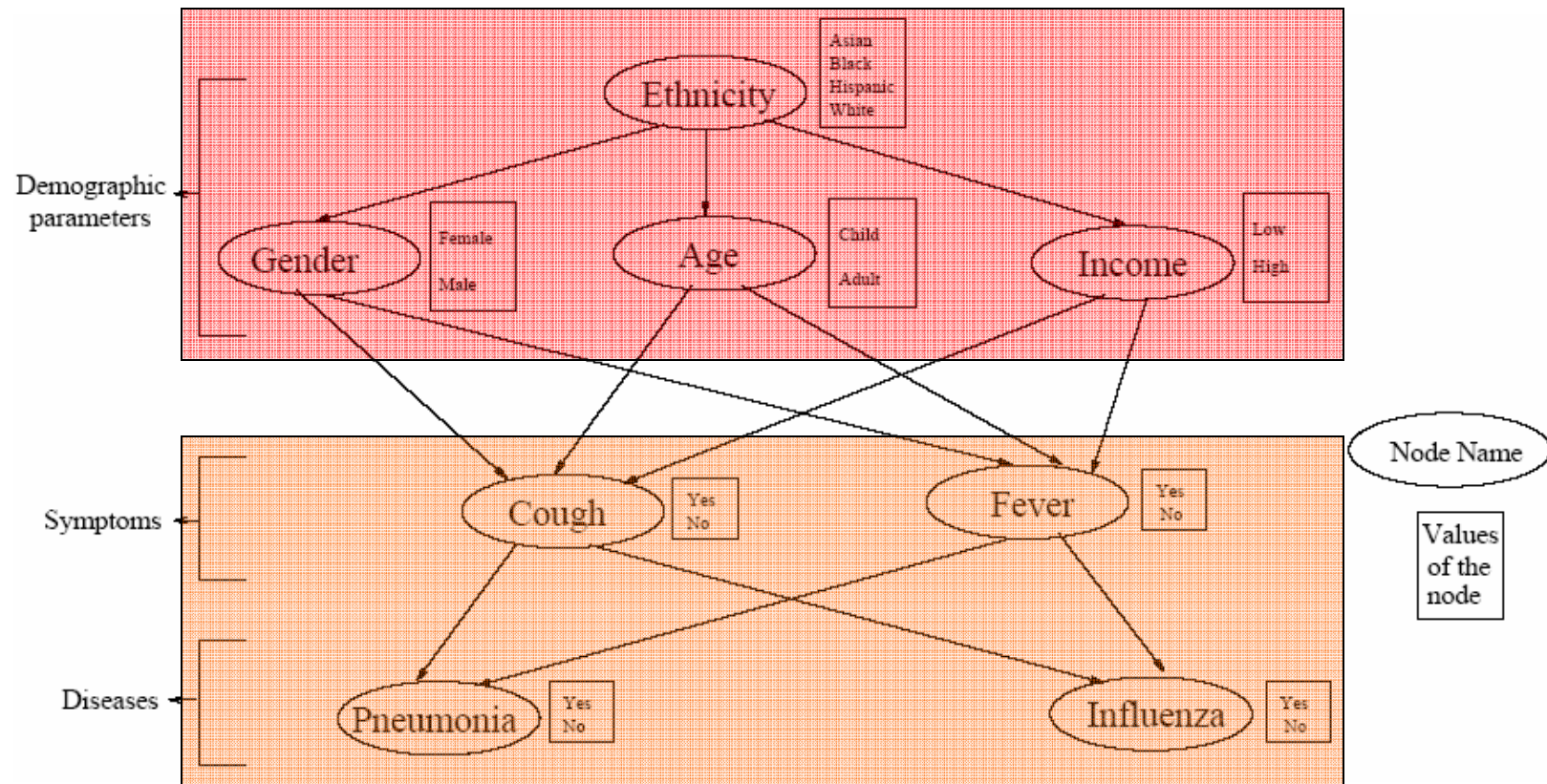
Table 2. Probability Distributions of Demographics for Scenario I

E	P(E)	G	E	P(G/E)	A	E	P(A/E)	I	E	P(I/E)
As	0.15	Fe	As	0.55	Ch	As	0.25	Lo	As	0.40
Bl	0.20	Fe	Bl	0.60	Ch	Bl	0.15	Lo	Bl	0.55
Hi	0.30	Fe	Hi	0.46	Ch	Hi	0.30	Lo	Hi	0.30
Wh	0.35	Fe	Wh	0.56	Ch	Wh	0.23	Lo	Wh	0.35
		Ma	As	0.45	Ad	As	0.75	Hi	As	0.60
		Ma	Bl	0.40	Ad	Bl	0.85	Hi	Bl	0.45
		Ma	Hi	0.54	Ad	Hi	0.70	Hi	Hi	0.70
		Ma	Wh	0.44	Ad	Wh	0.77	Hi	Wh	0.65

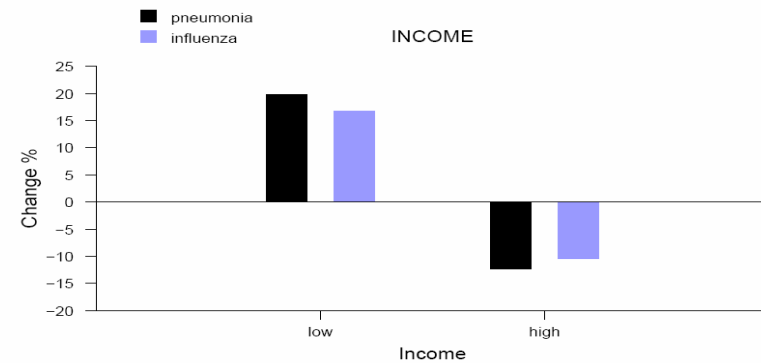
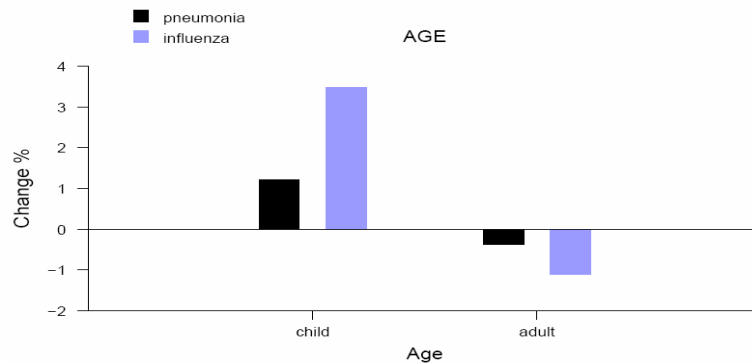
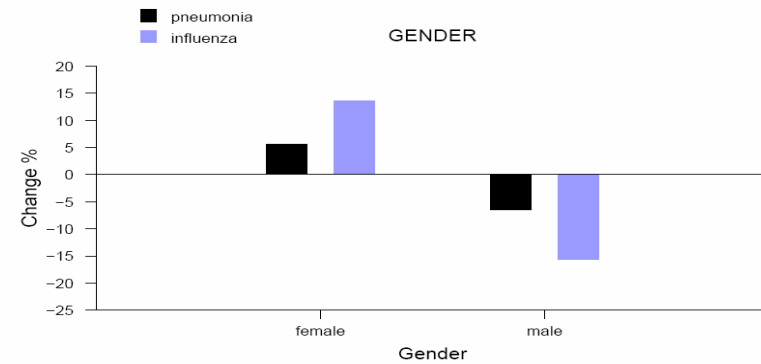
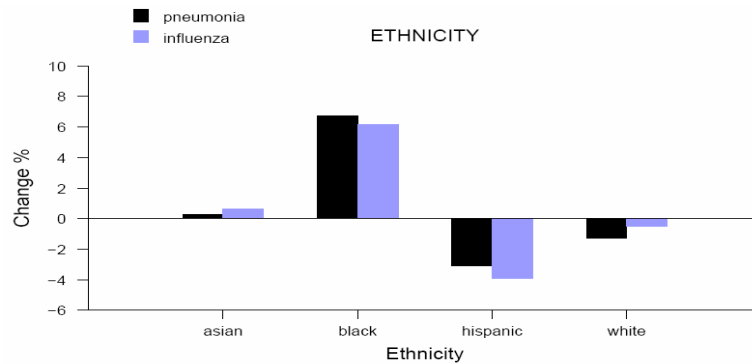
Table 3. Probability Distributions of Symptoms and Diseases

G	A	I	P(C/G,A,I)	G	A	I	P(F/G,A,I)
Fe	Ch	Lo	0.35	Fe	Ch	Lo	0.75
Fe	Ch	Hi	0.25	Fe	Ch	Hi	0.40
Fe	Ad	Lo	0.88	Fe	Ad	Lo	0.44
Fe	Ad	Hi	0.05	Fe	Ad	Hi	0.85
Ma	Ch	Lo	0.15	Ma	Ch	Lo	0.54
Ma	Ch	Hi	0.85	Ma	Ch	Hi	0.64
Ma	Ad	Lo	0.54	Ma	Ad	Lo	0.27
Ma	Ad	Hi	0.64	Ma	Ad	Hi	0.20
			P(C/C,F)				P(IN/C,F)
	C	F			C	F	
	Ye	Ye	0.30		Ye	Ye	0.25
	Ye	No	0.10		Ye	No	0.05
	No	Ye	0.10		No	Ye	0.10
	No	No	0.001		No	No	0.00

Geographic Region I: Bayesian Network



Geographic Region I: Analysis

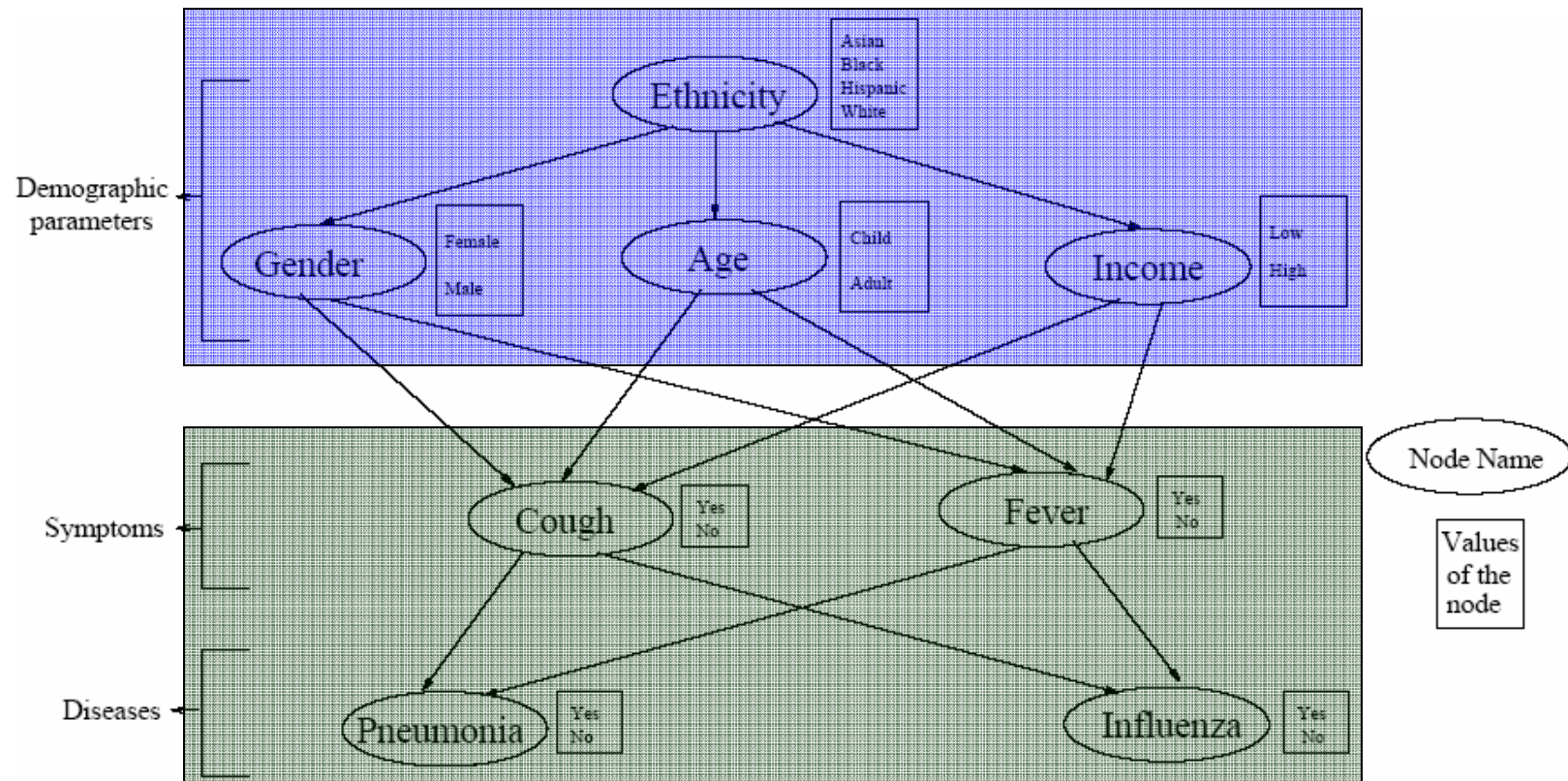


Geographic Region II: Probability distributions

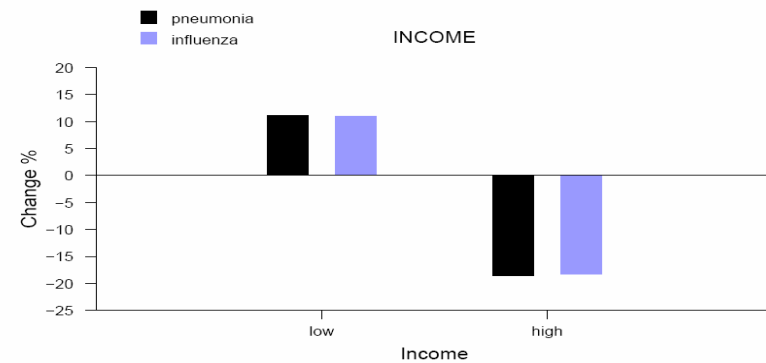
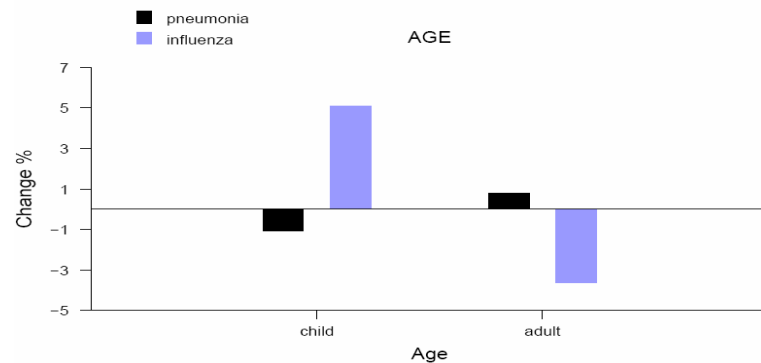
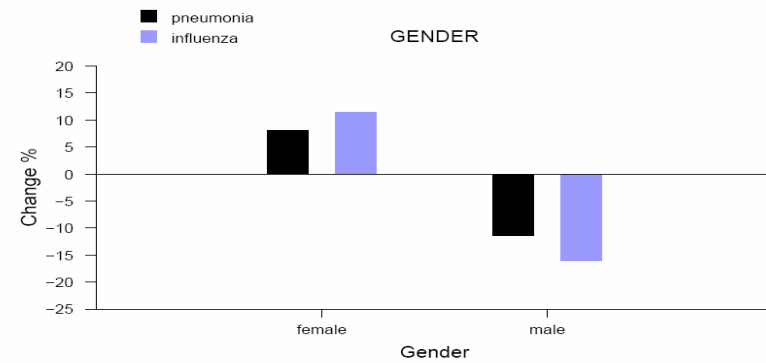
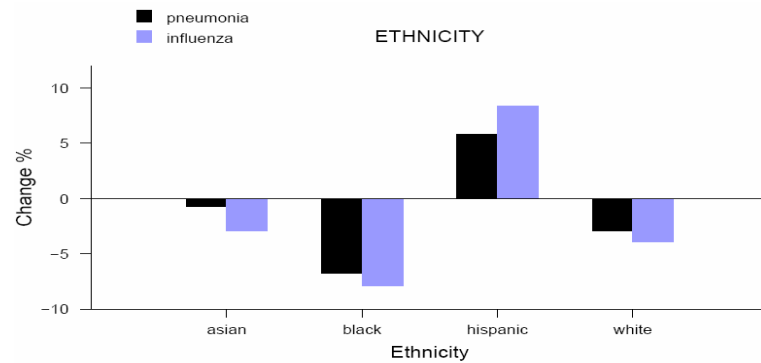
Table 4. Probability Distributions of Demographics for Scenario II

E	P(E)	G	E	P(G/E)	A	E	P(A/E)	I	E	P(I/E)
As	0.20	Fe	As	0.60	Ch	As	0.15	Lo	As	0.55
Bl	0.15	Fe	Bl	0.55	Ch	Bl	0.25	Lo	Bl	0.40
Hi	0.35	Fe	Hi	0.75	Ch	Hi	0.60	Lo	Hi	0.75
Wh	0.30	Fe	Wh	0.40	Ch	Wh	0.46	Lo	Wh	0.64
		Ma	As	0.40	Ad	As	0.85	Hi	As	0.45
		Ma	Bl	0.45	Ad	Bl	0.75	Hi	Bl	0.60
		Ma	Hi	0.25	Ad	Hi	0.40	Hi	Hi	0.25
		Ma	Wh	0.60	Ad	Wh	0.54	Hi	Wh	0.36

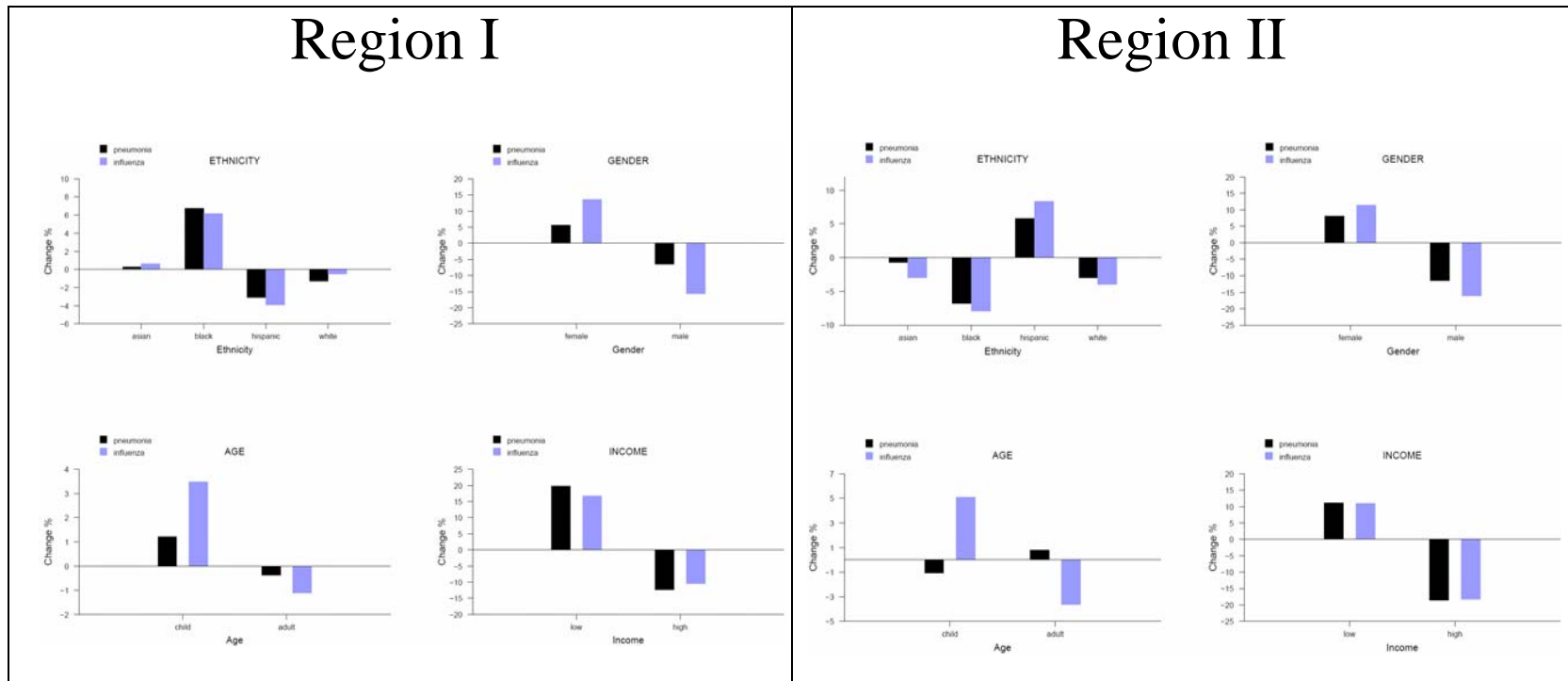
Geographic Region II: Bayesian Network



Geographic Region II: Analysis



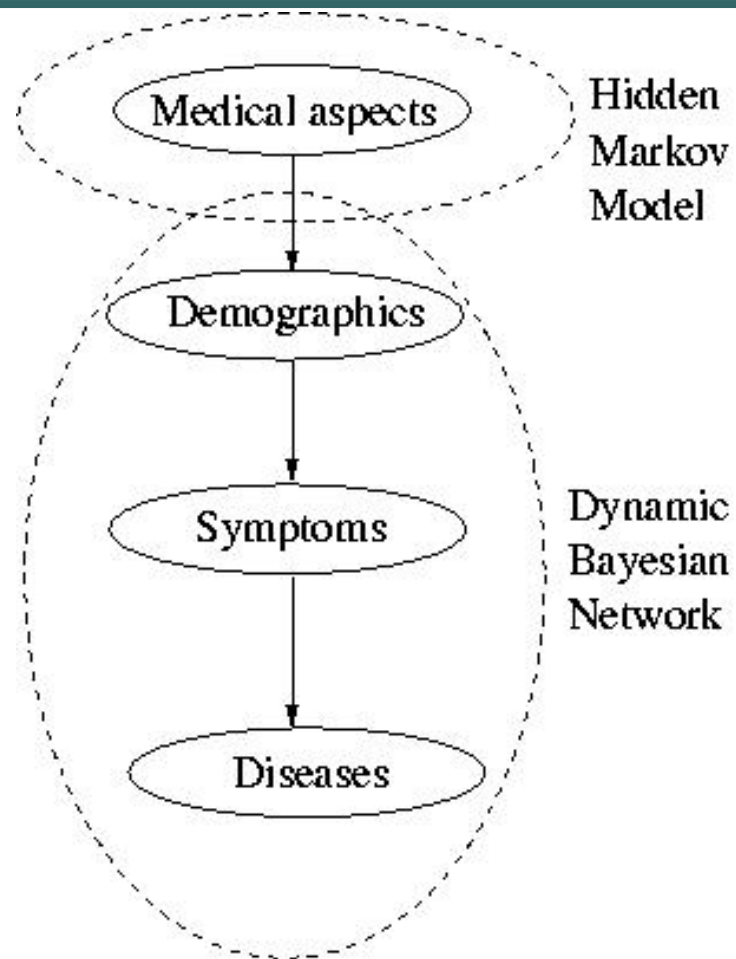
Regional Comparison of Inferences



Summary

- SIR Model
 - Lack of demographic analysis
- Bayesian Epidemic Model
 - Demographic analysis
 - Spatial portability of inferences

Current Work



Discussion, Questions & Comments

Computational Epidemiology: Bayesian Disease Surveillance

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