

Anatomy of MERS epidemic

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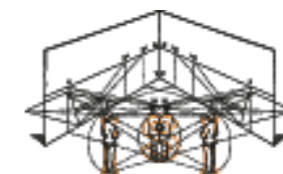
ISI Foundation
Turin, Italy

Inserm



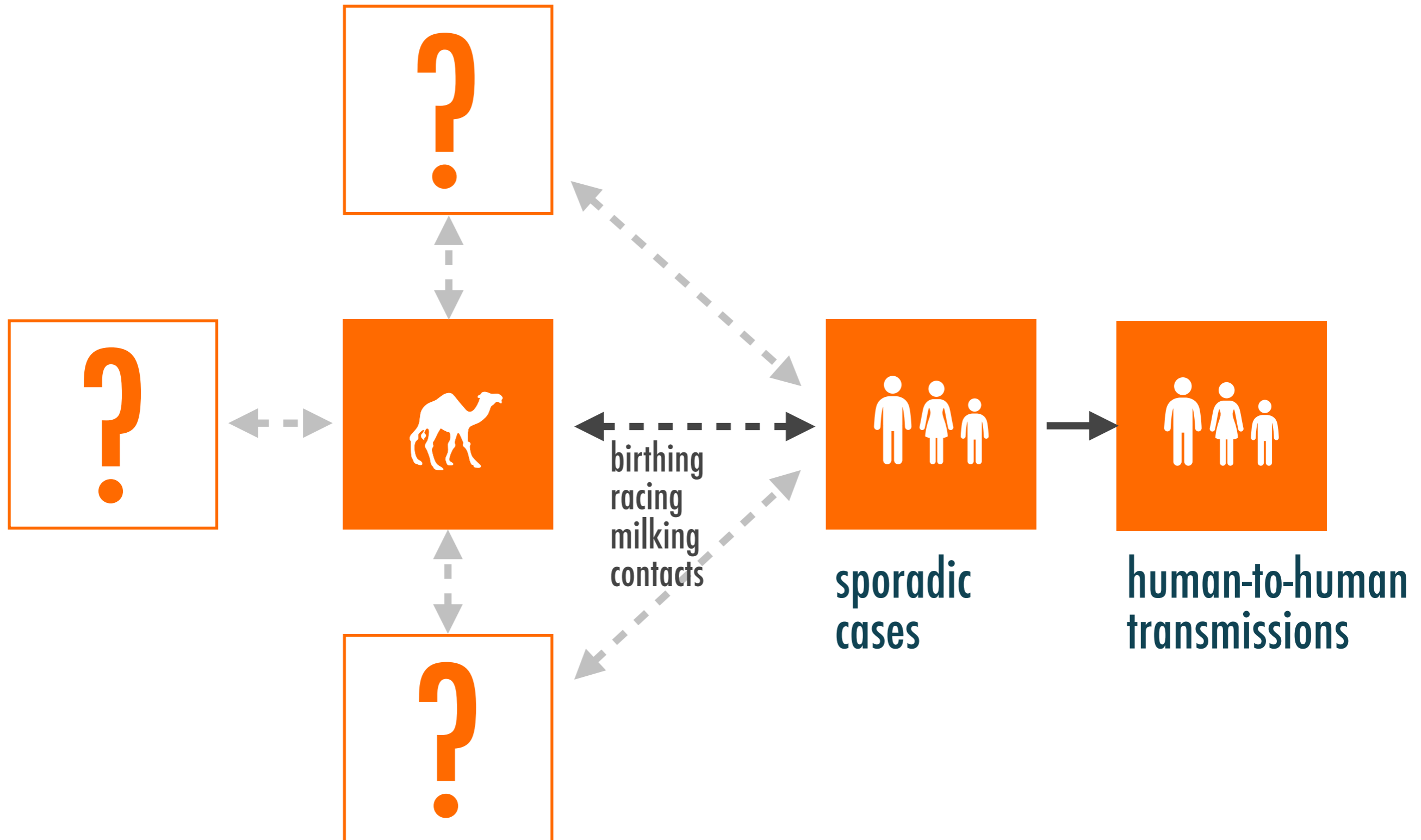
Institut national
de la santé et de la recherche médicale

UPMC
PARISUNIVERSITAS

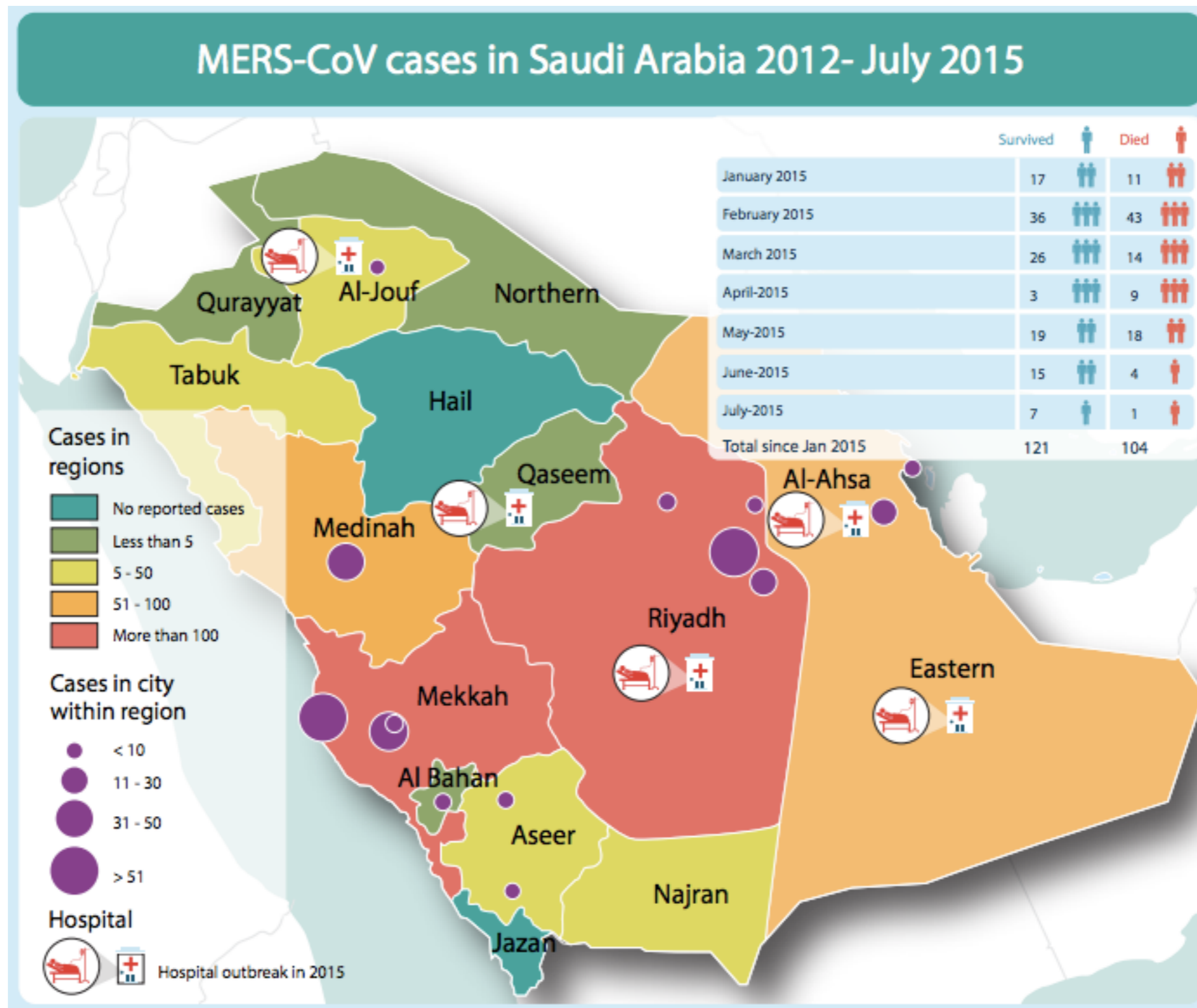


ISI Foundation

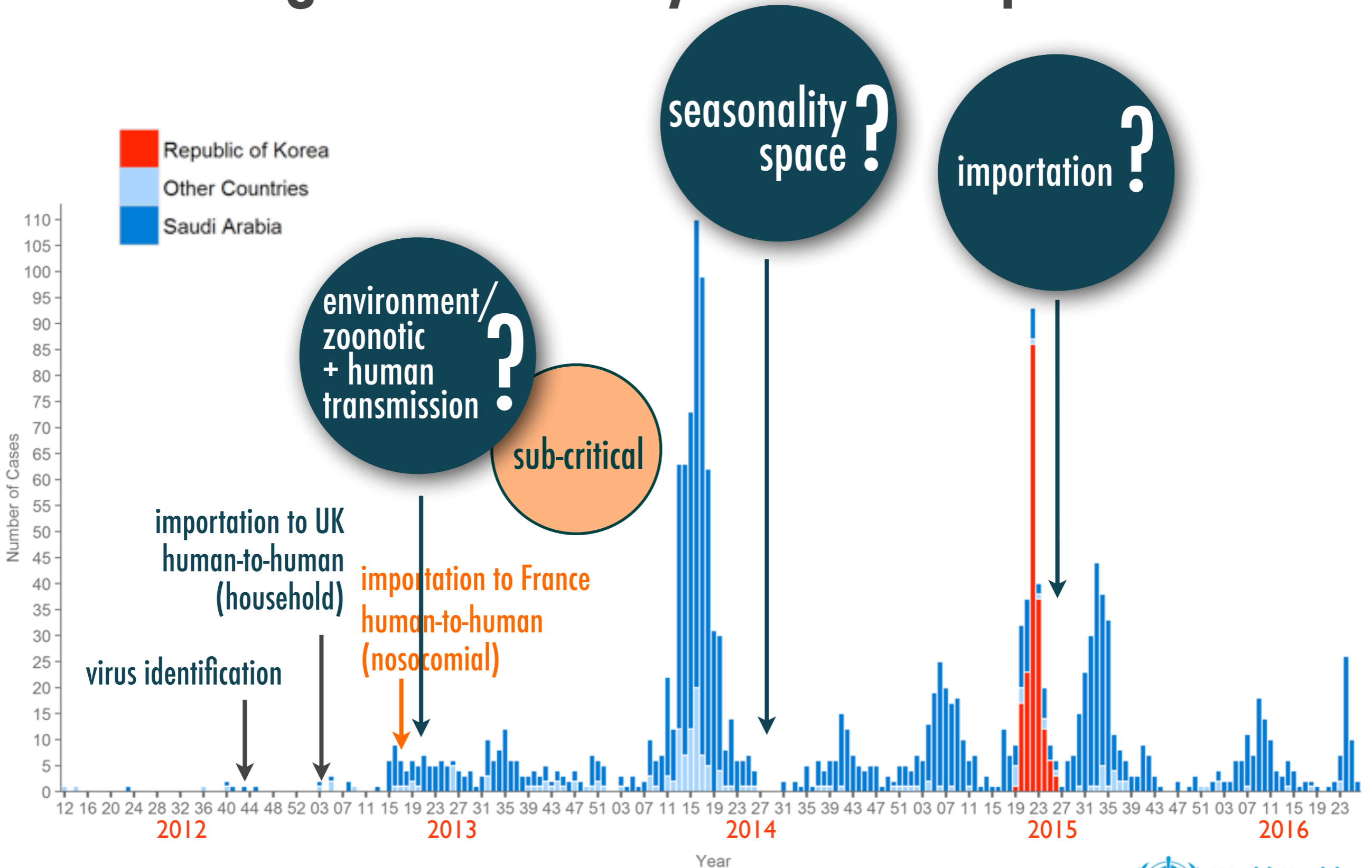
MERS ecology



MERS geography



uncovering the anatomy of MERS epidemic

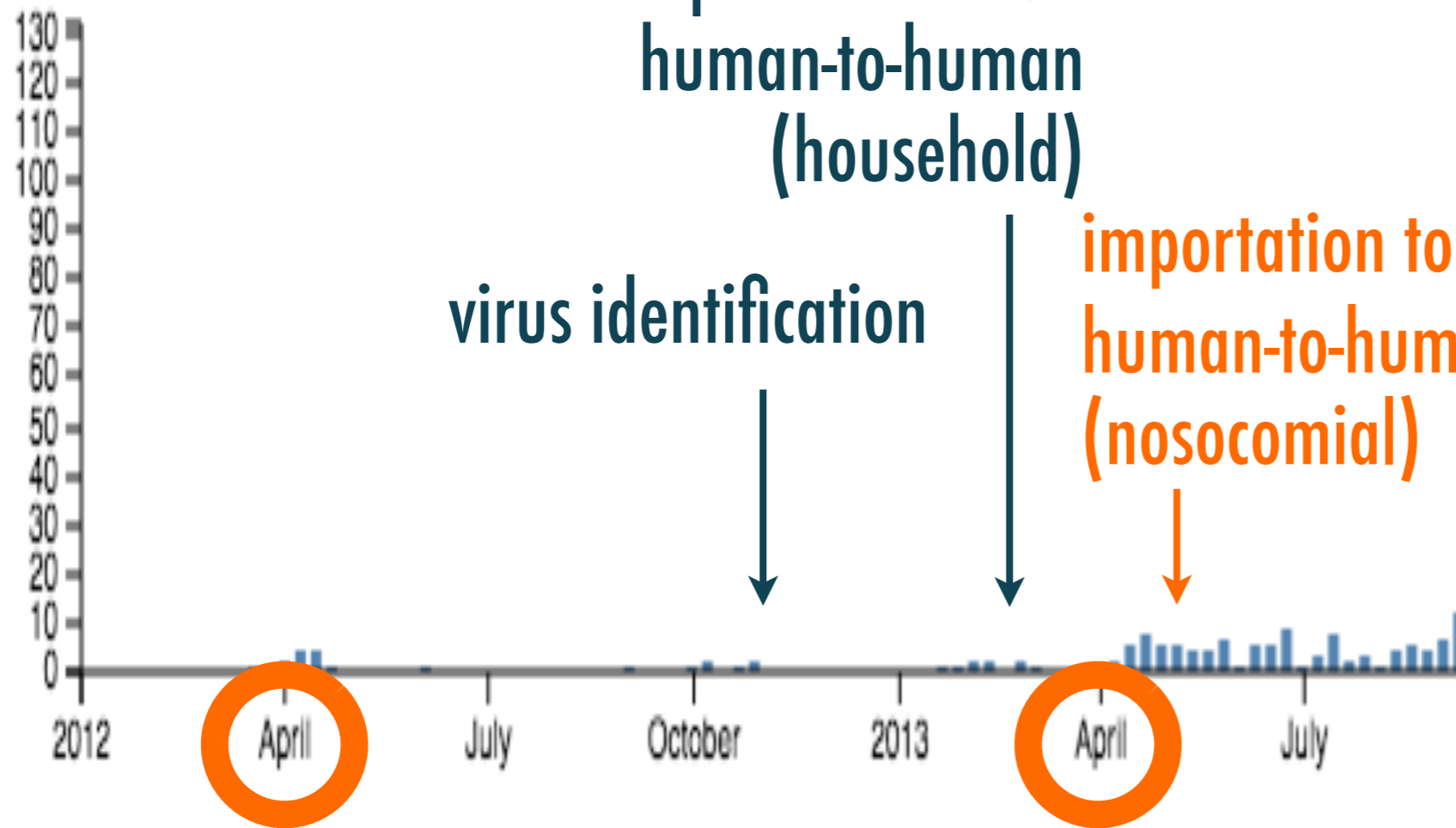


Other countries: Algeria, Austria, Bahrain, China, Egypt, France, Germany, Greece, Iran, Italy, Jordan, Kuwait, Lebanon, Malaysia, Netherlands, Oman, Philippines, Qatar, Thailand, Tunisia, Turkey, United Arab Emirates, United Kingdom, United States of America, Yemen
 Please note that the underlying data is subject to change as the investigations around cases are ongoing. Onset date estimated if not available.

Spring 2014

seasonality
space ?

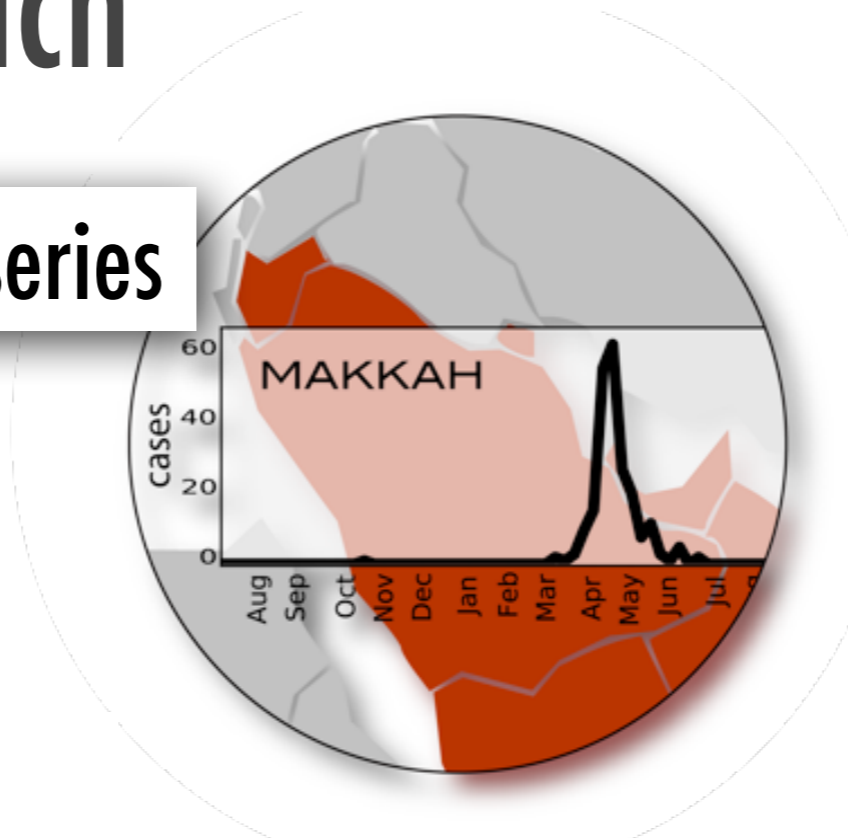
cases by date



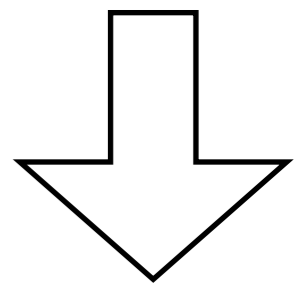
integrated approach

incidence time series

1

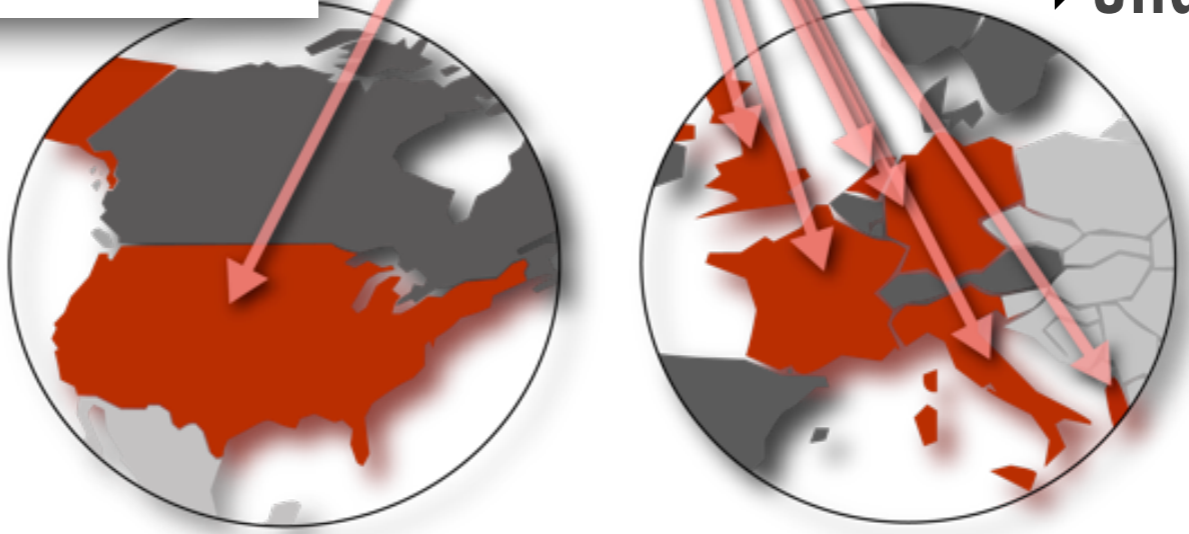


- ▶ generation sporadic cases $\rho_{sp}^r(t)$
- ▶ human transmissions $R^r(t)$



seasonality space

case importation



▶ underascertainment ρ

■ countries with $n_j=0$
■ countries with $n_j>0$

geo-temporal variation

$$p_{sp}^r = \alpha_r p_{zoon}$$

$$R^r = \beta_r R$$

spatial
dependence

temporal
dependence

p_{sp}

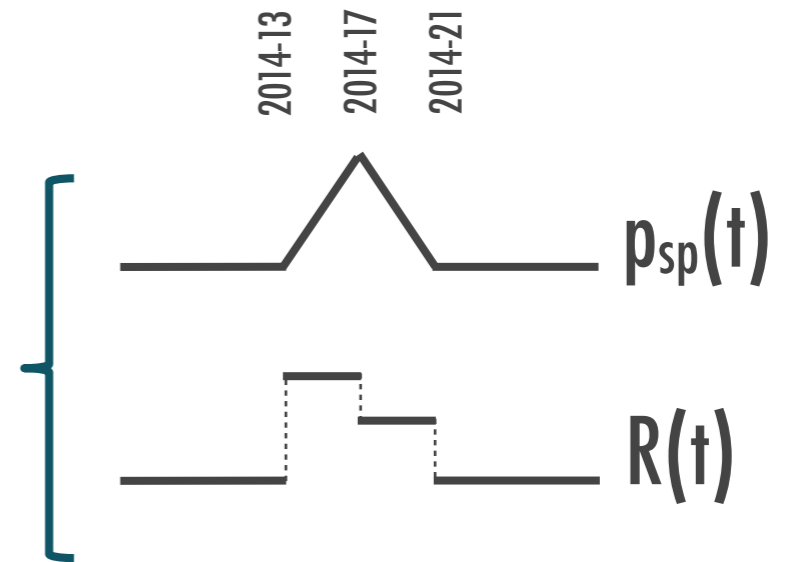
?

?

R

?

?

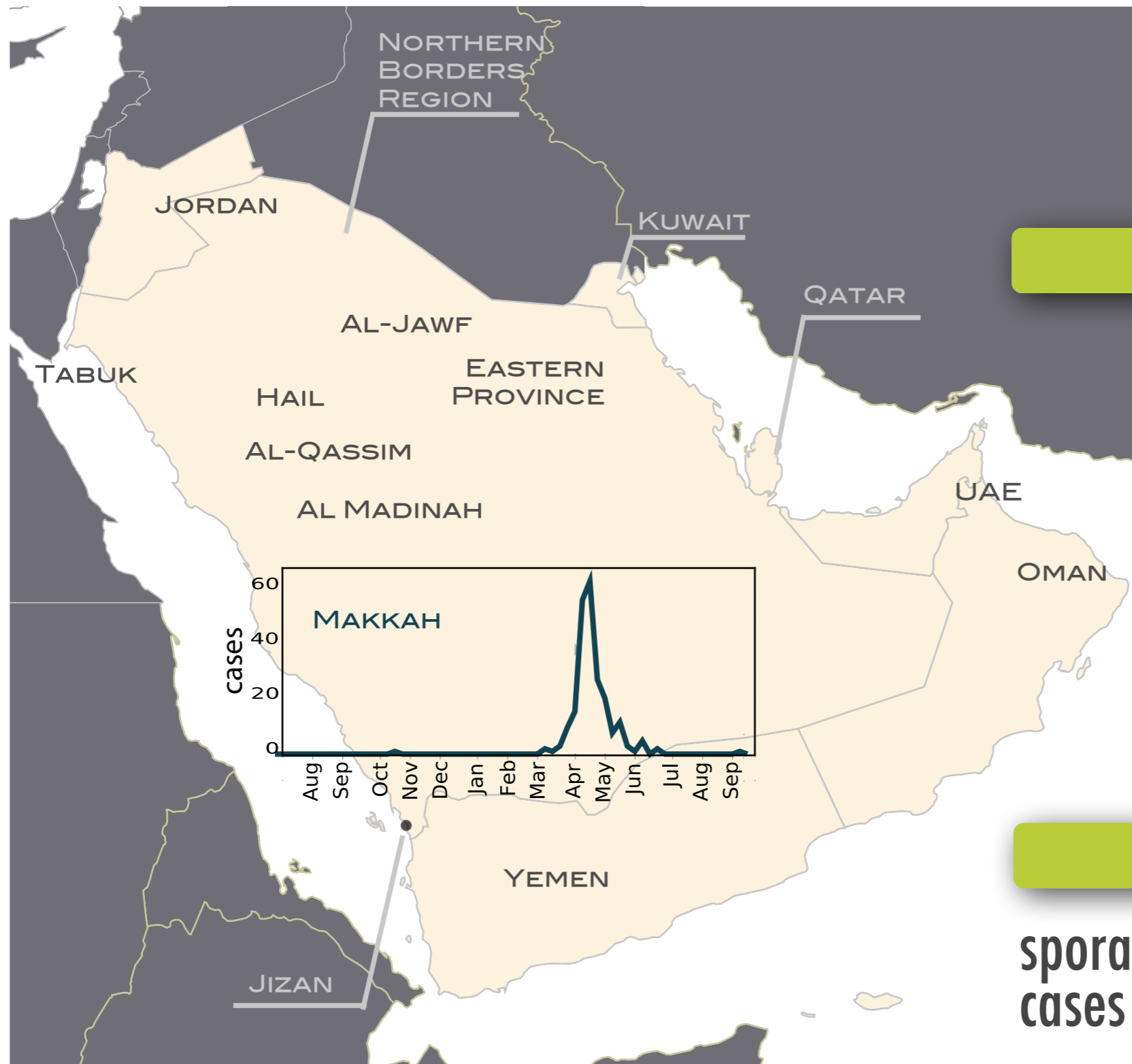


17 regions



11 provinces Saudi Arabia
Qatar
Oman
Kuwait
Jordan
UAE
Yemen

onset time series of cases incidence



complete info scenario

66%

34%

sporadic cases

transmissions

[WHO]

partial info scenario

>34%

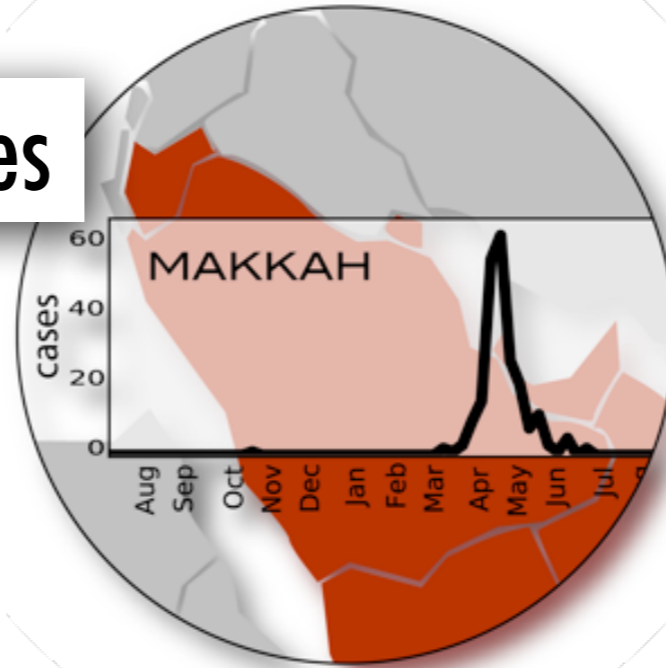
sporadic cases

transmissions

integrated approach

incidence time series

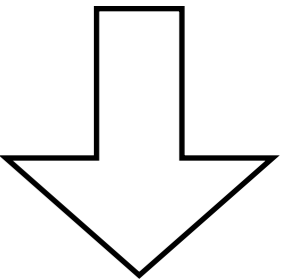
1



▶ generation sporadic cases $\rho_{sp}^r(t)$

▶ human transmissions $R^r(t)$

best fit values



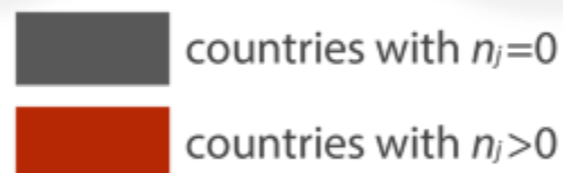
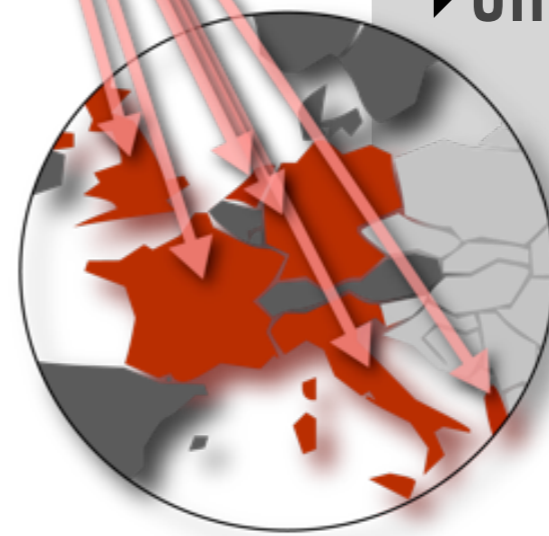
▶ underascertainment

ρ

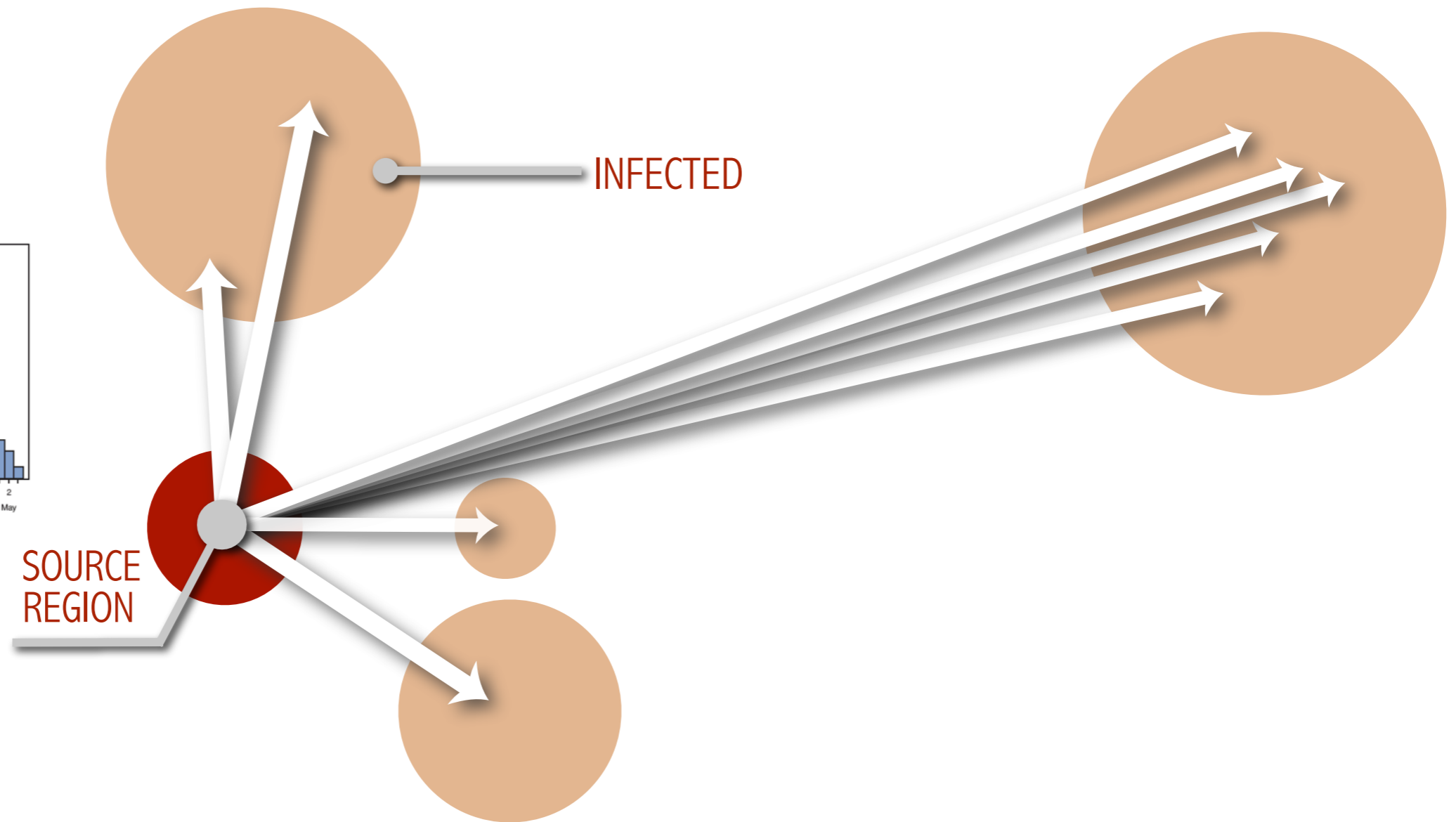
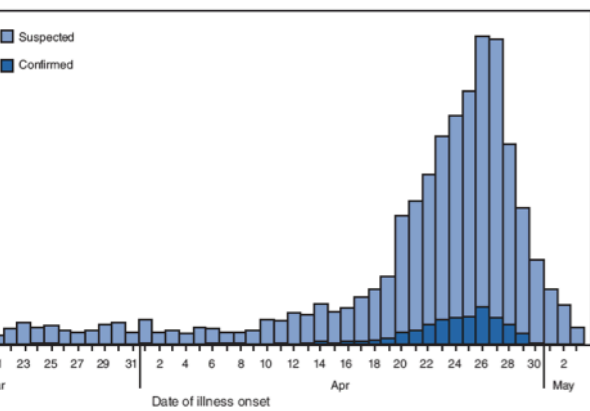
seasonality space

case importation

2

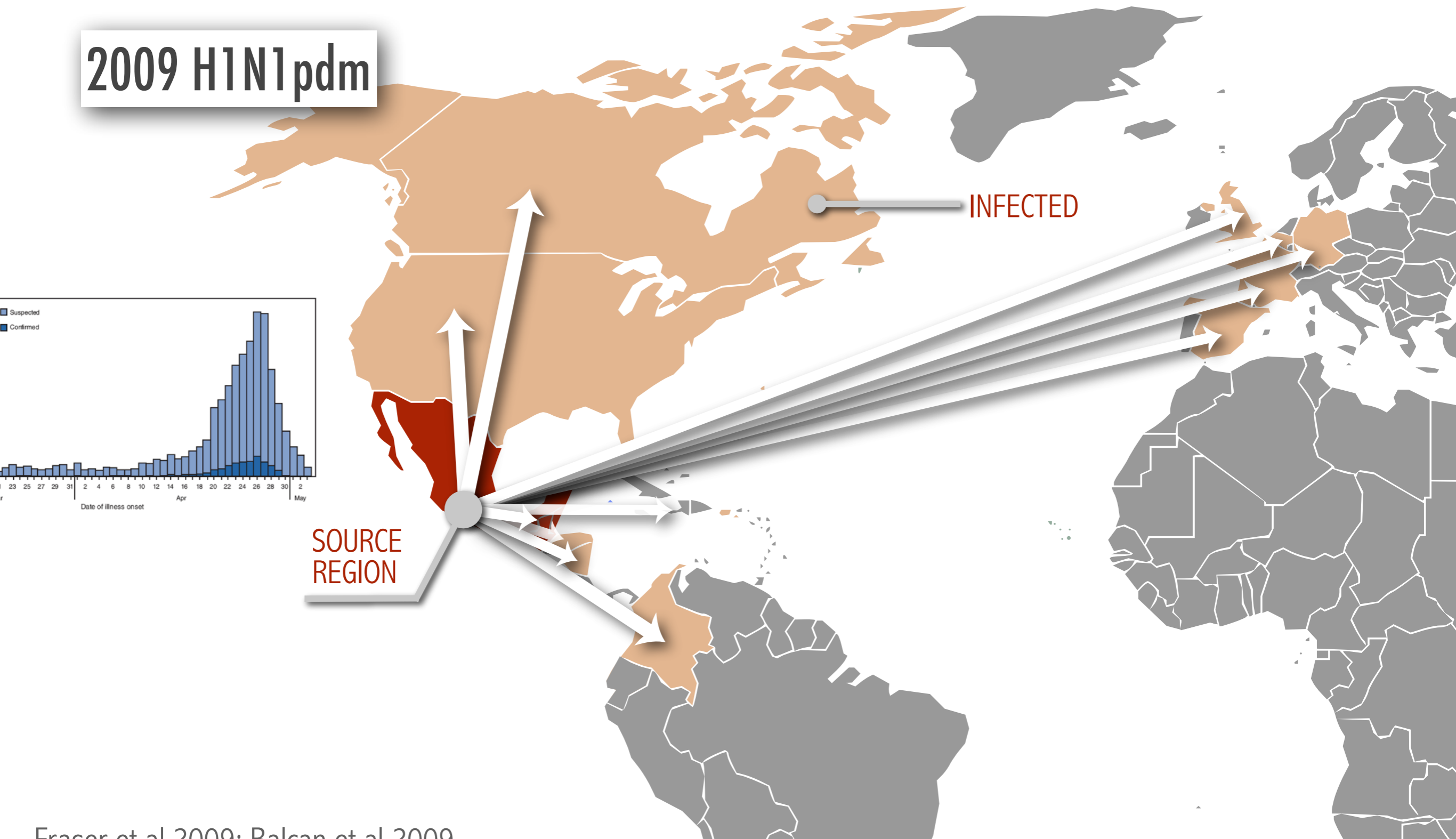


estimating ρ from importations



estimating ρ from importations

2009 H1N1 pdm



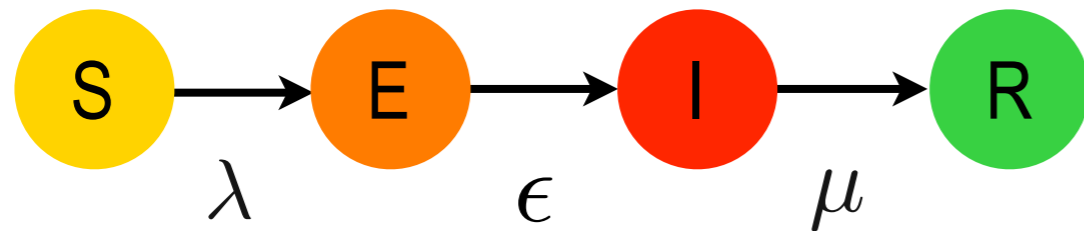


CHARTING THE NEXT PANDEMIC



GLEAMViz.org

sporadic + human-to-human transmission



5.2d: latency

7.6d: generation time

Assiri et al 2013

force of infection

$$\lambda = \lambda^{(SP)} + \lambda^{(H-H)}$$

↓

$$p_{sp}^r(t)$$

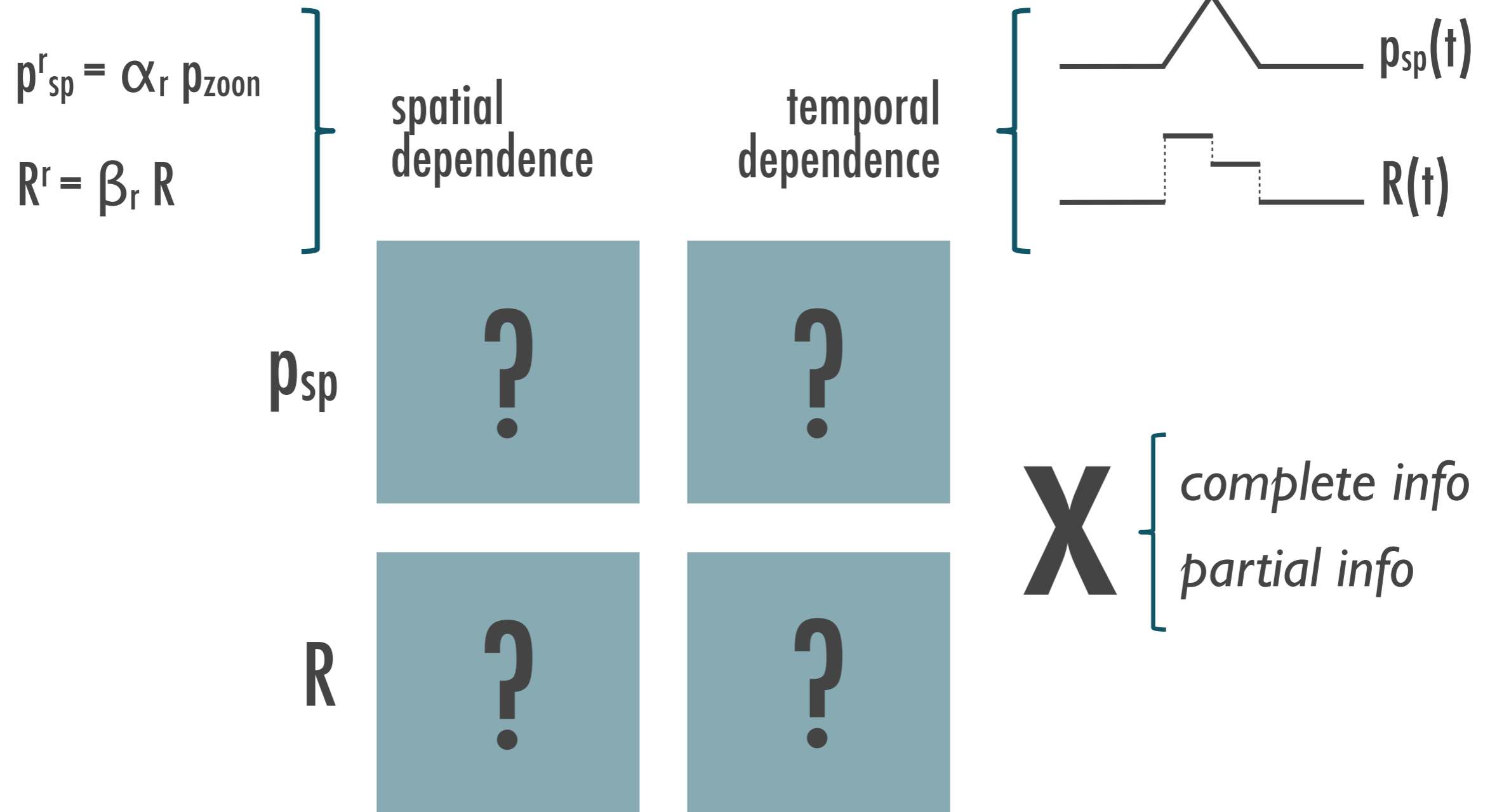
↓

$$R^r(t)$$

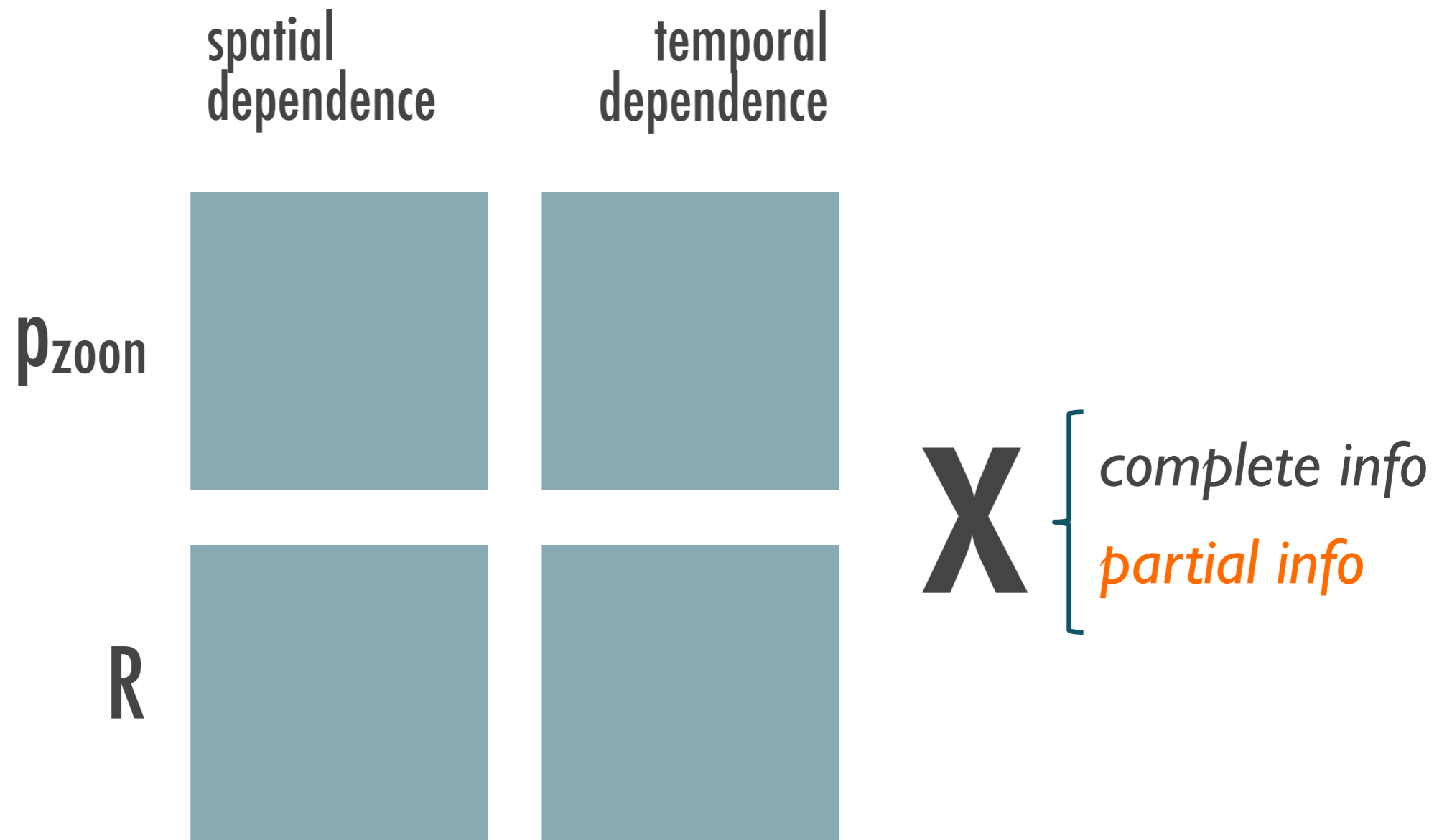
- ▶ number of cases $n^r(t)$
▶ notifications

$$D^r(t) = \rho n^r(t)$$





integrated approach: 32 models







results



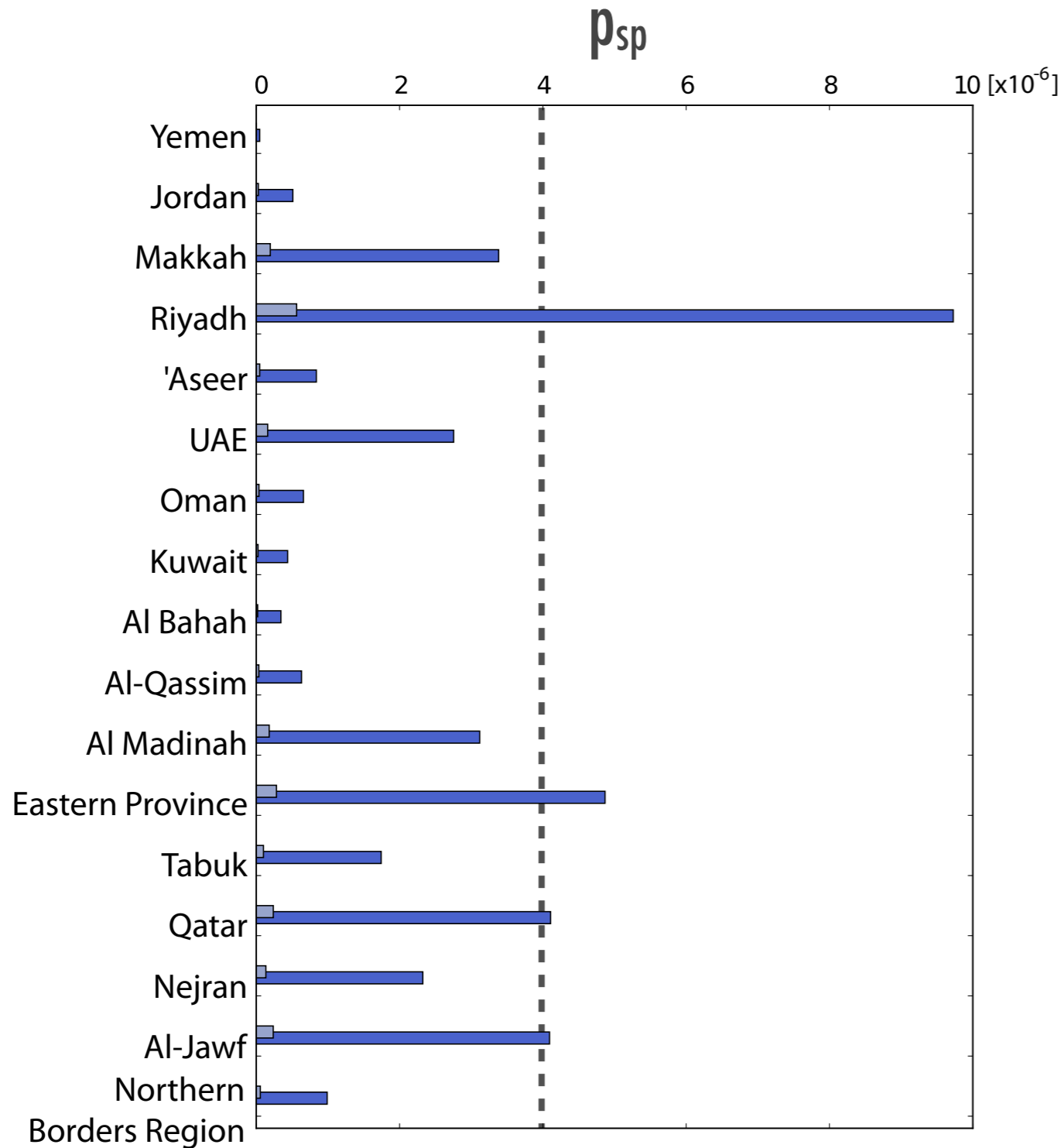
results

	spatial dependence	temporal dependence	
ρ_{zoon}			X { <i>complete info</i> <i>partial info</i>
R			

results

	spatial dependence	temporal dependence	
ρ_{zoon}			X { <i>complete info</i> <i>partial info</i>
R			

geo-temporal variation

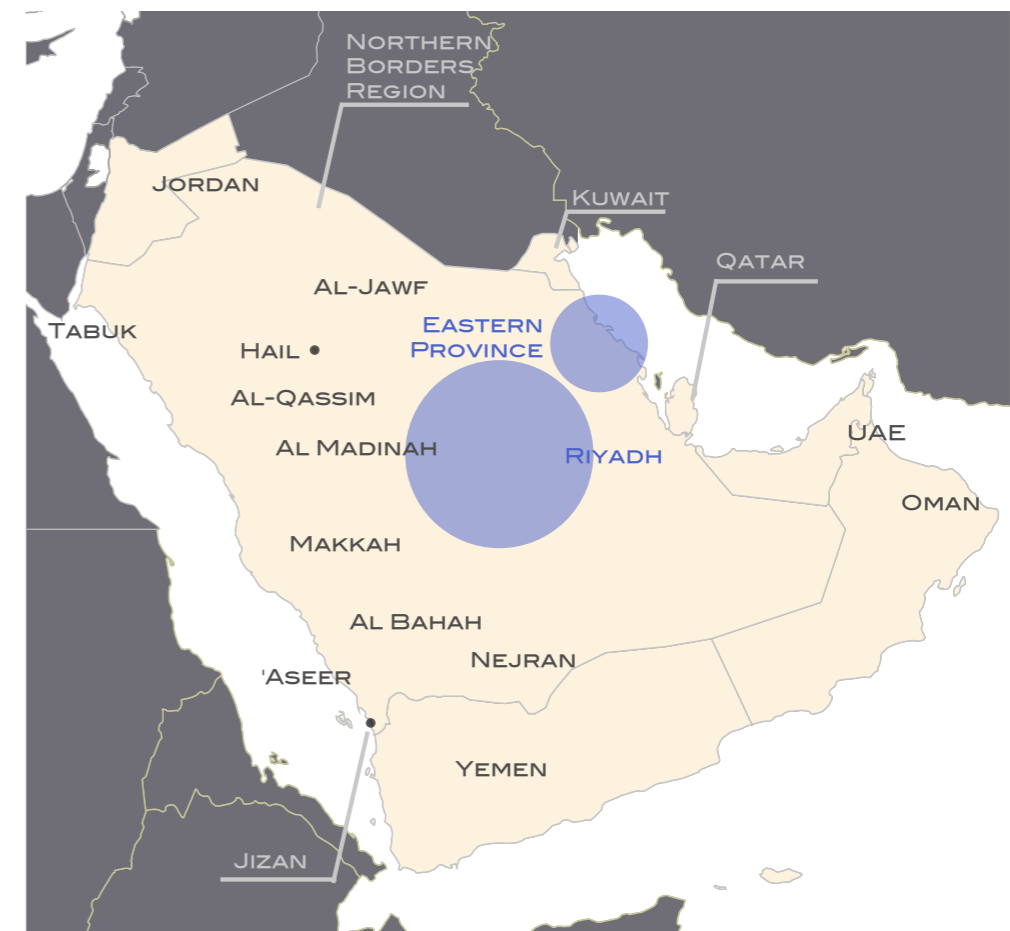


R

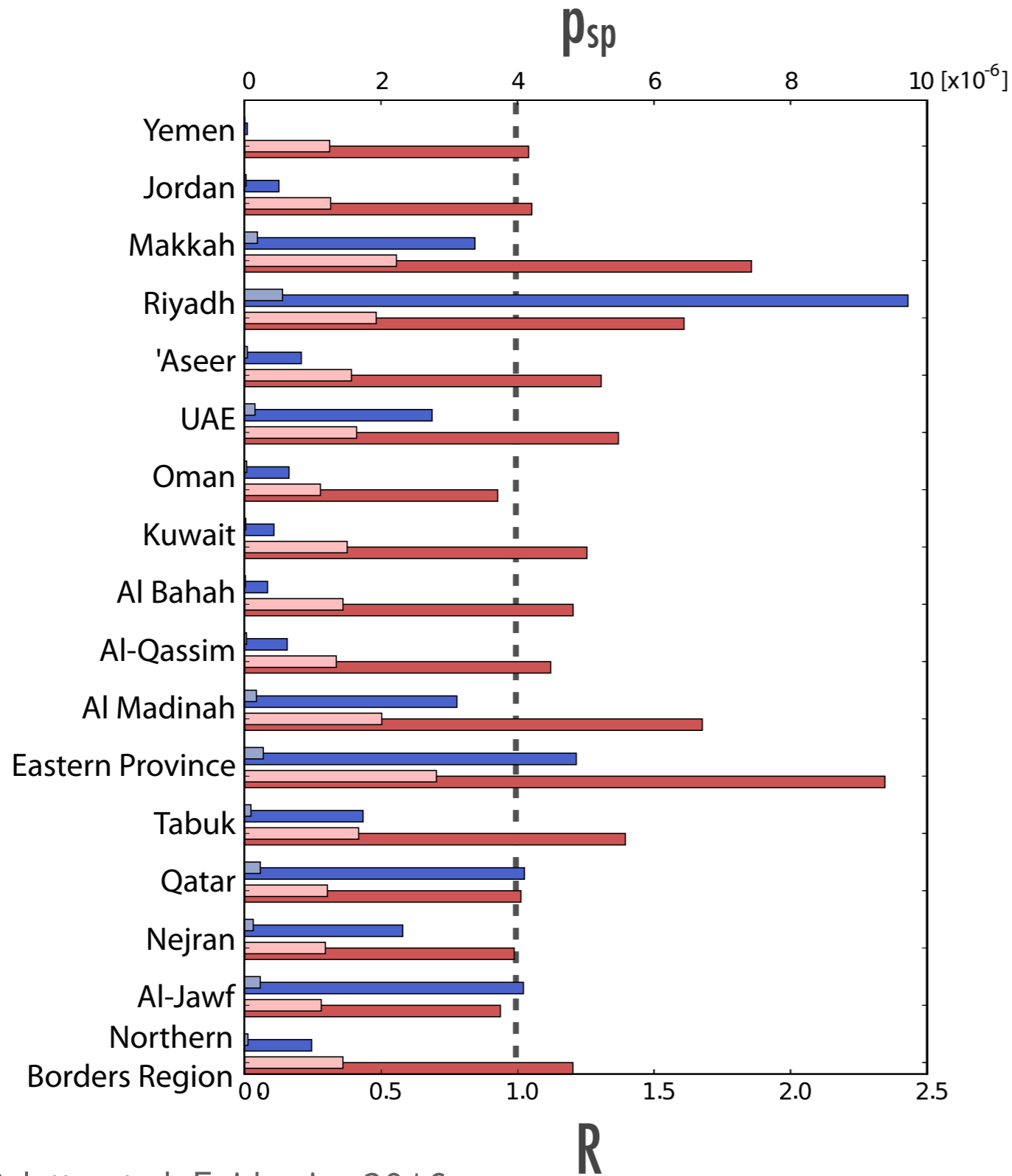
p_{sp}

baseline \rightarrow Spring 2014
 6/week \rightarrow 108/week
 ~17-fold increase

acute epidemics in calves in Spring: Wernery et al 2015



geo-temporal variation

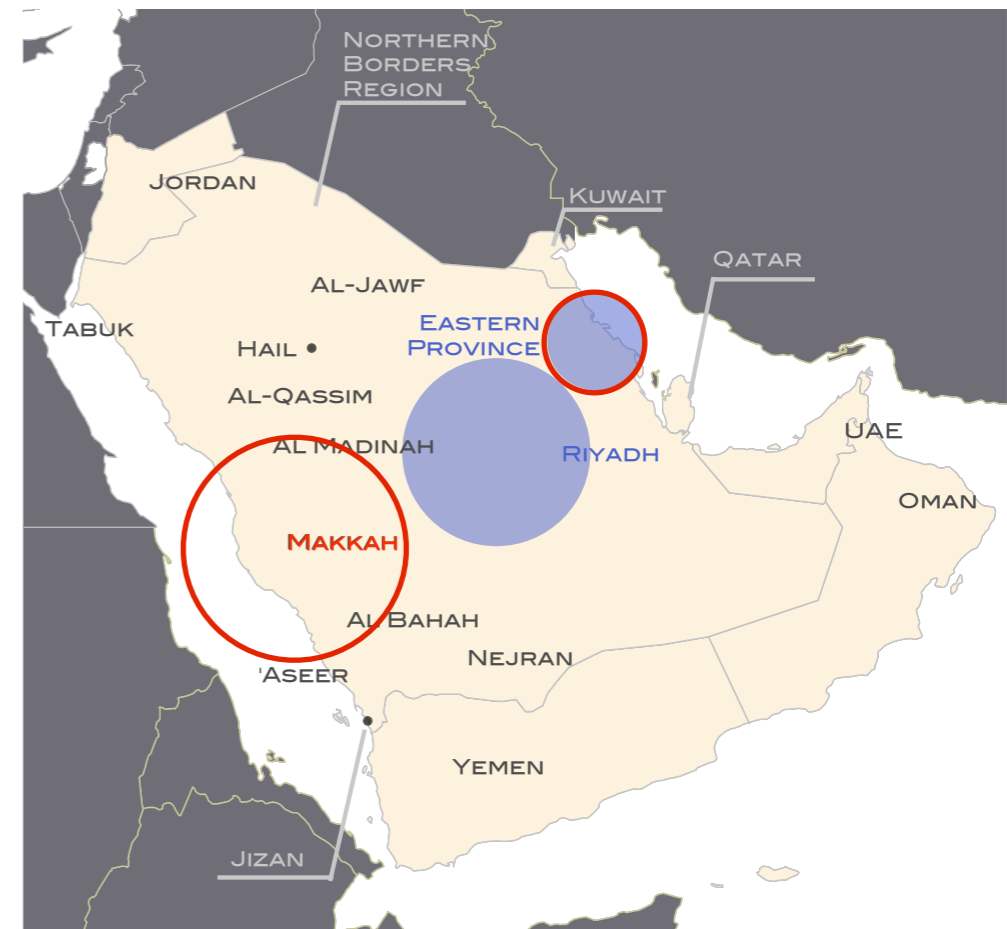


Poletto et al, Epidemics 2016

p_{sp}

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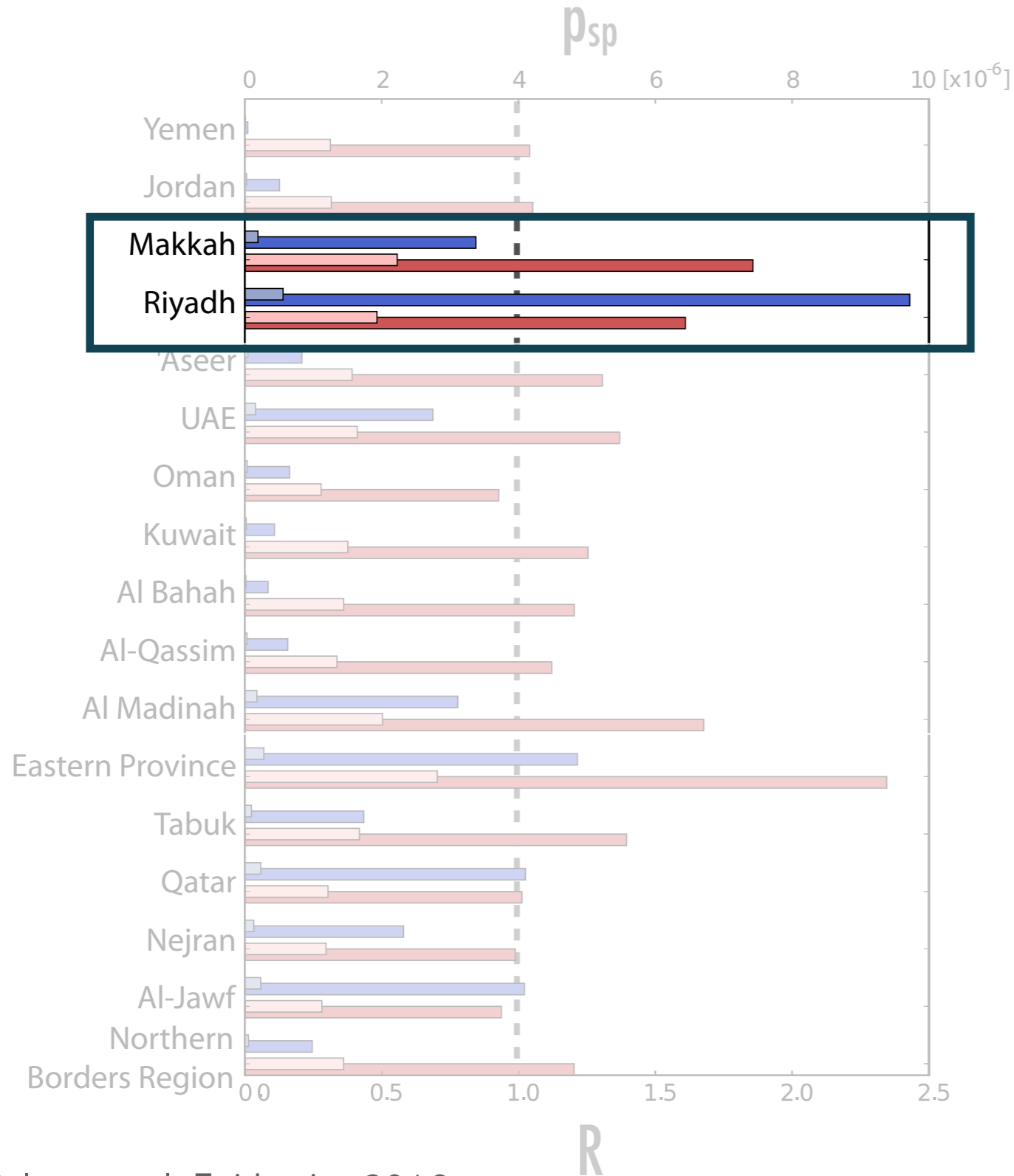
acute epidemics in calves in Spring: Wernery et al 2015



R

baseline → Spring 2014
 ~3-fold increase

geo-temporal variation

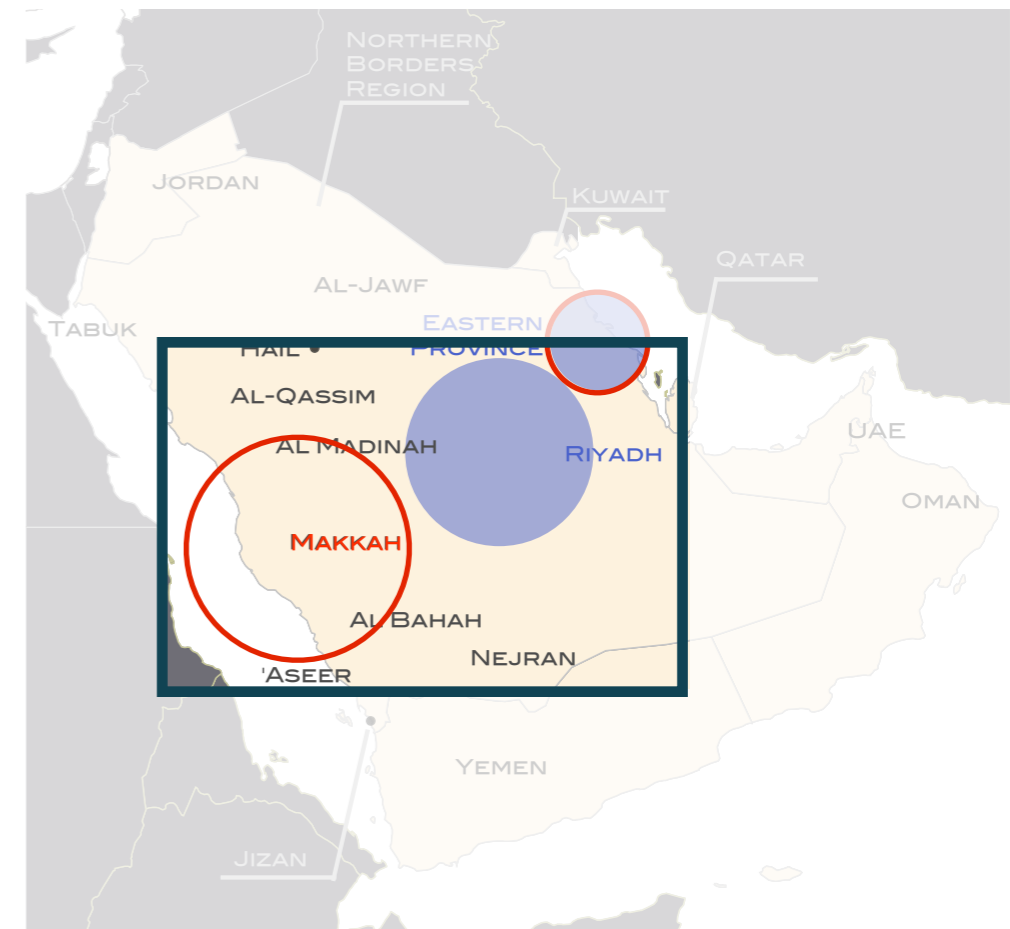


Poletto et al, Epidemics 2016

p_{sp}

baseline → Spring 2014
 ~6/week → ~108/week
 ~17-fold increase

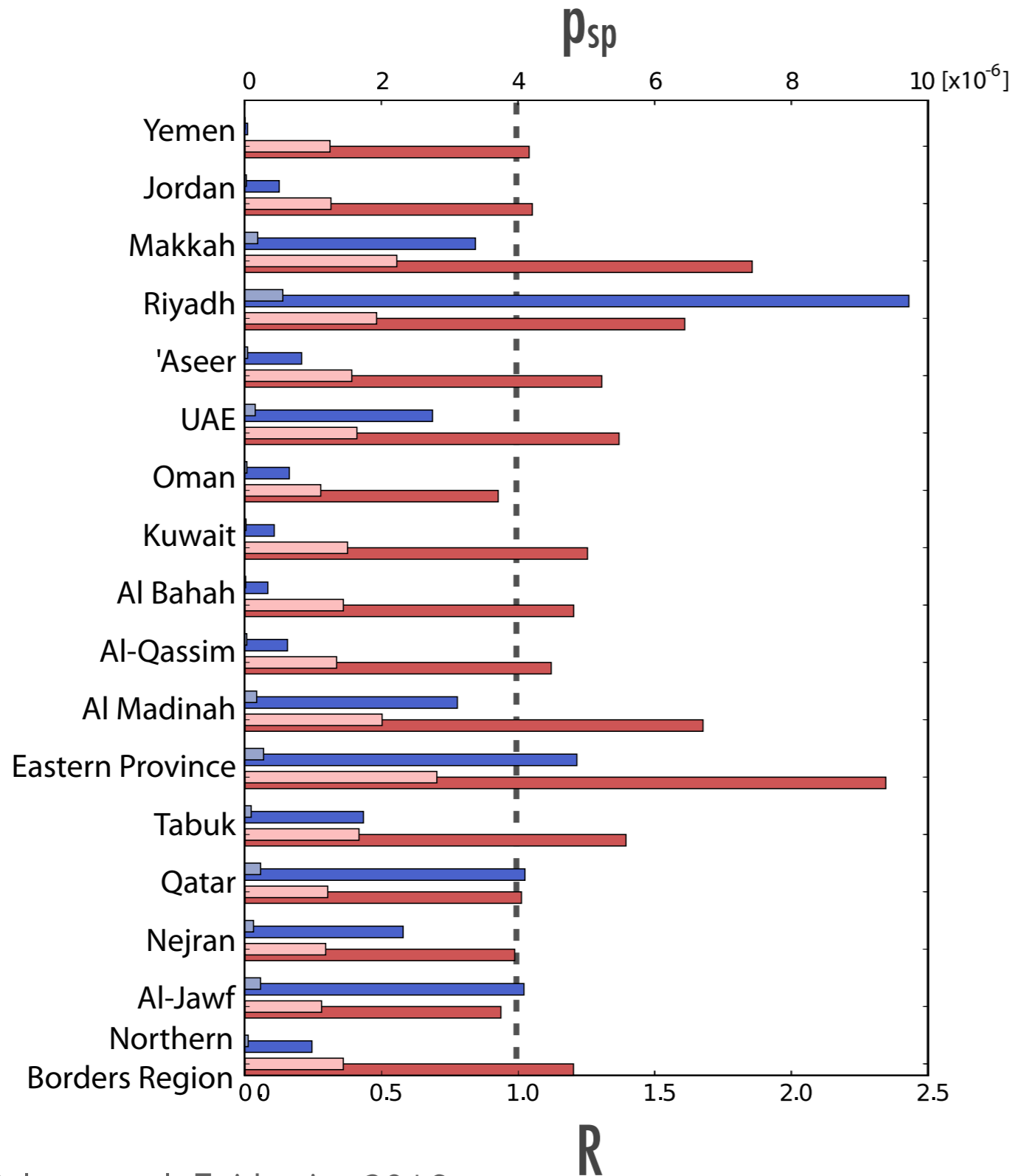
acute epidemics in calves in Spring: Wernery et al 2015



R

baseline → Spring 2014
 ~3-fold increase

geographical variation



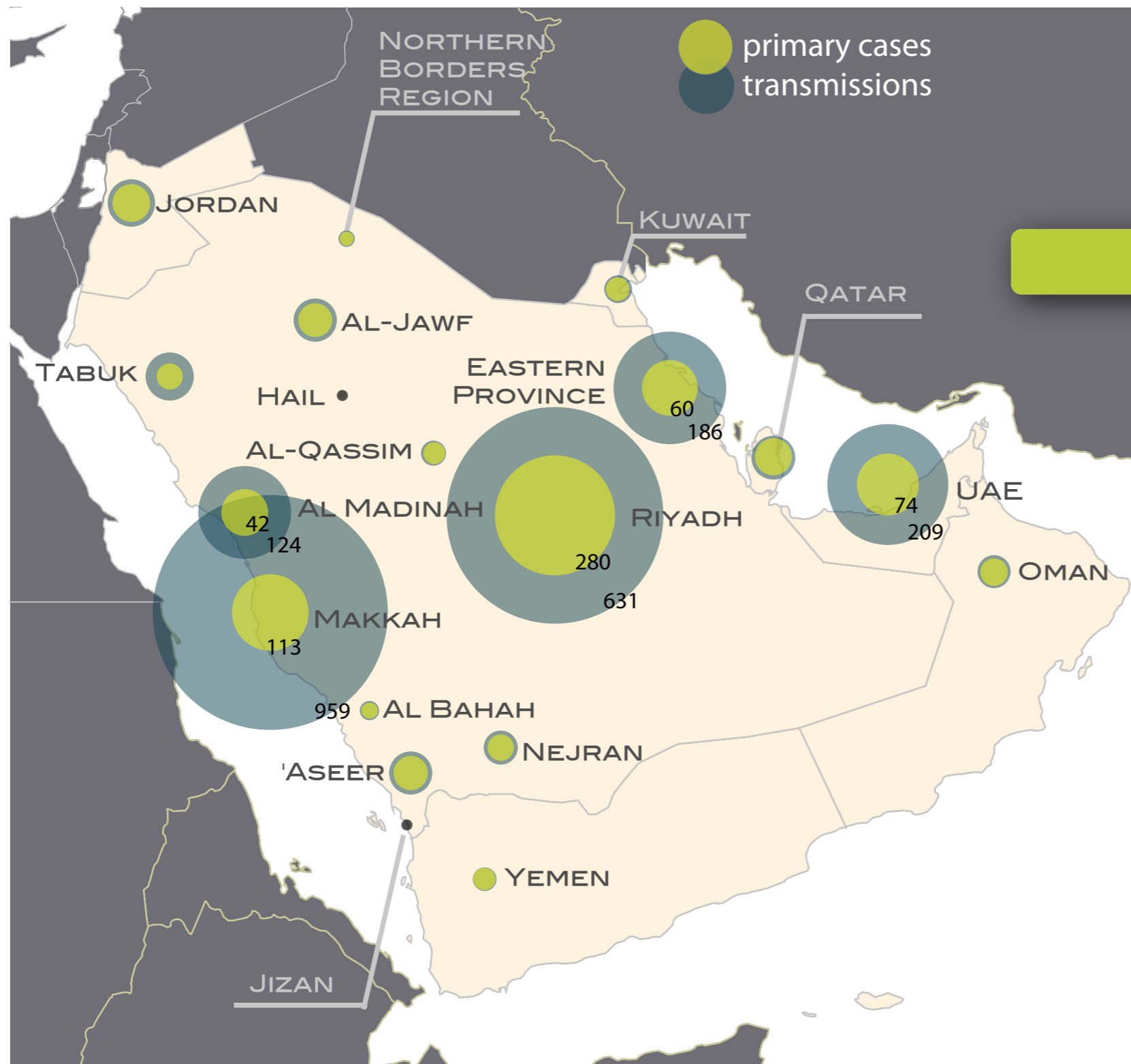
p_{sp}

baseline → Spring 2014
coefficient of variation: **0.99**

R

baseline → Spring 2014
coefficient of variation: **0.20**

sporadic vs. human-transmission cases



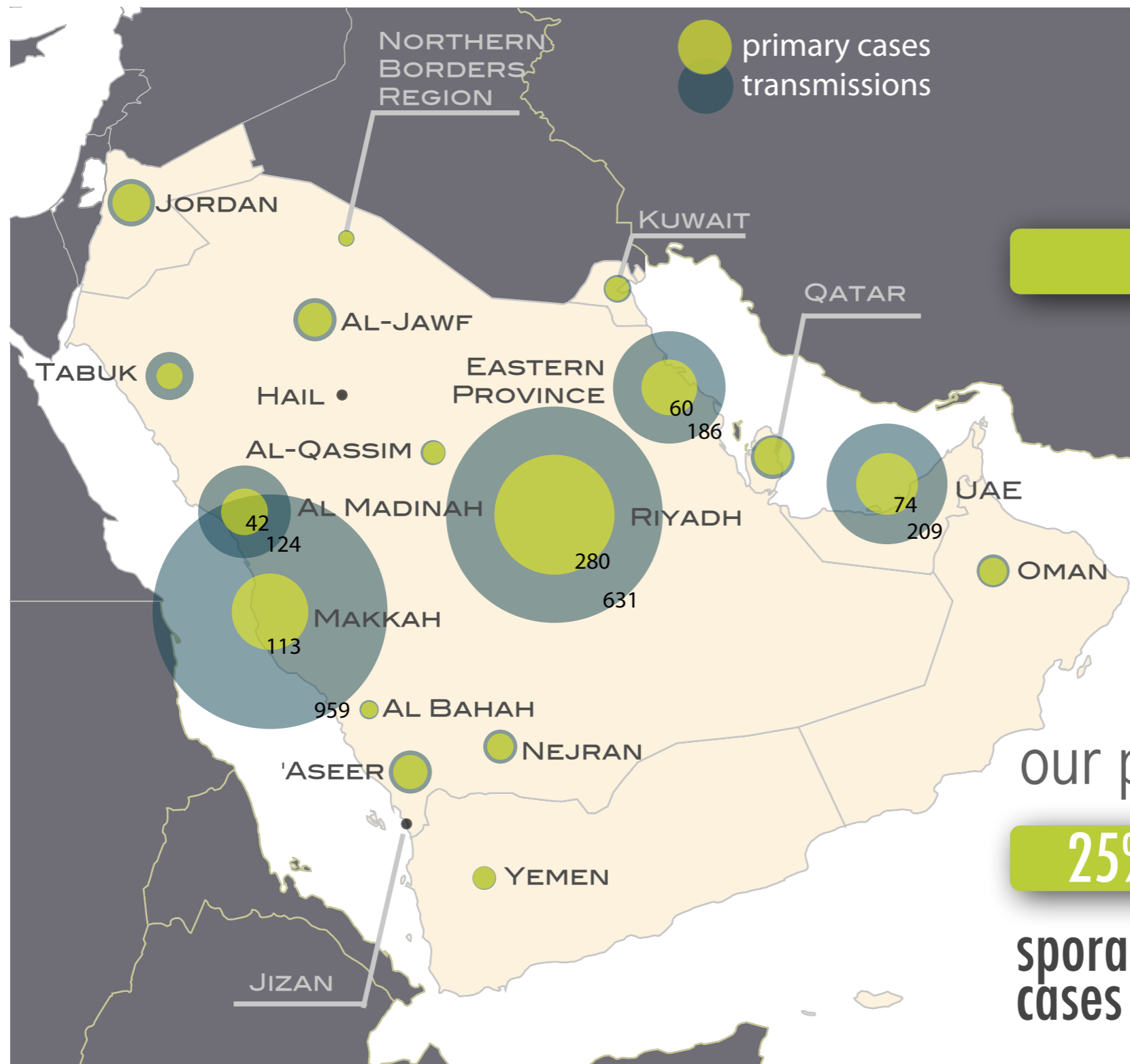
WHO:



sporadic cases

transmissions

sporadic vs. human-transmission cases



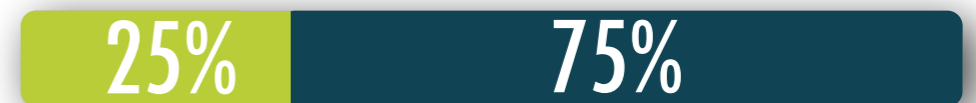
WHO:



sporadic cases

transmissions

our predictions:

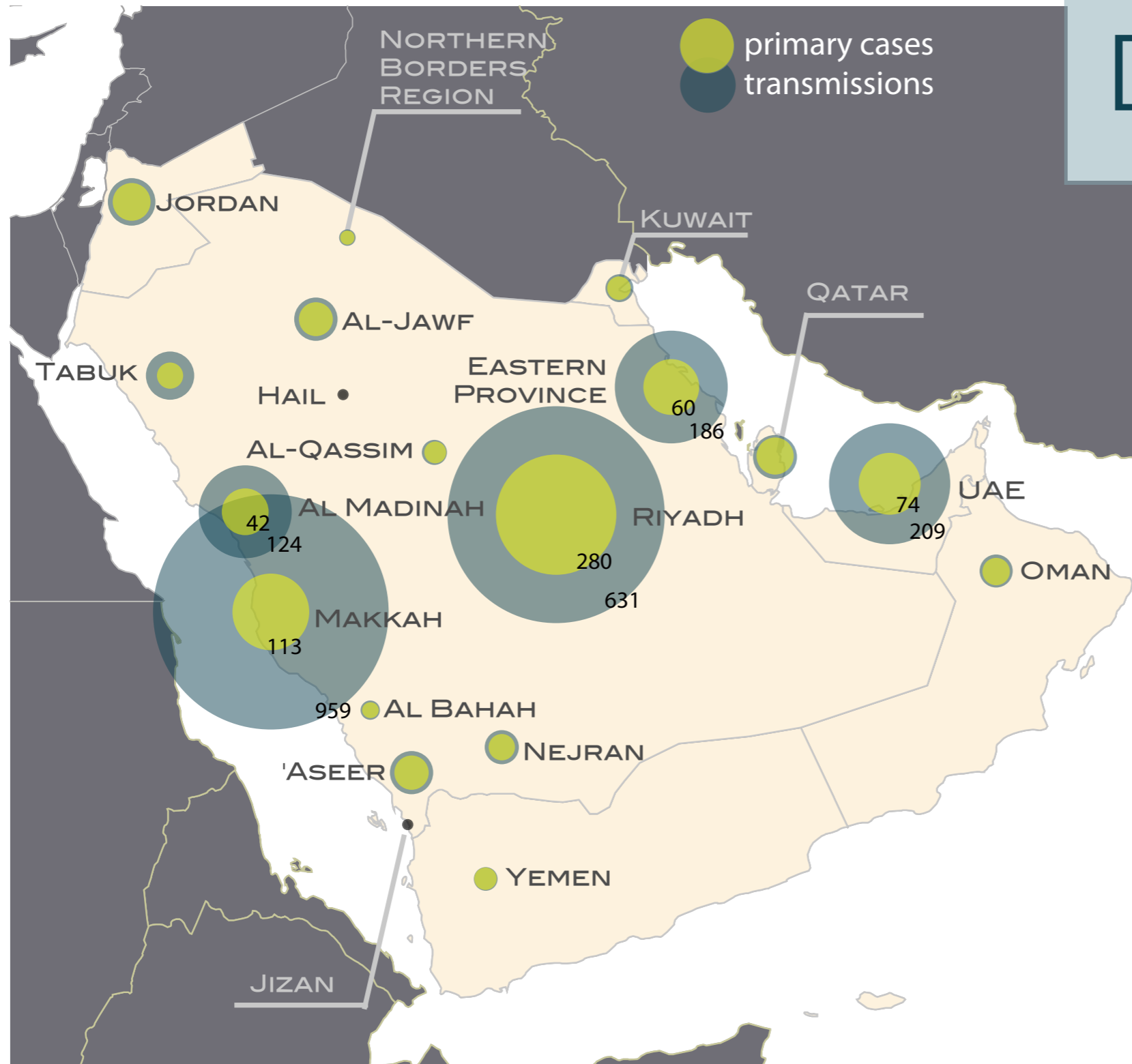


sporadic cases

transmissions

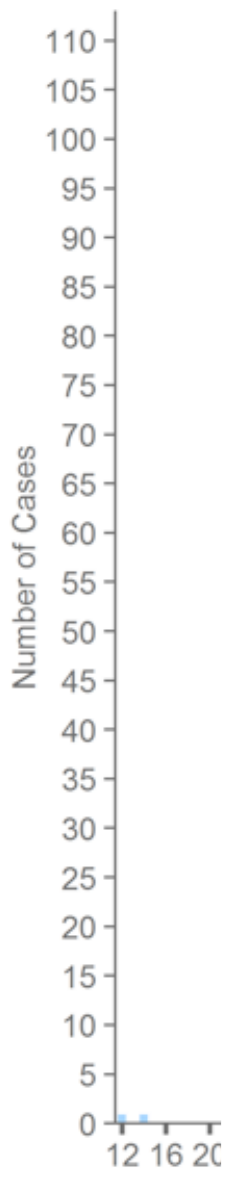
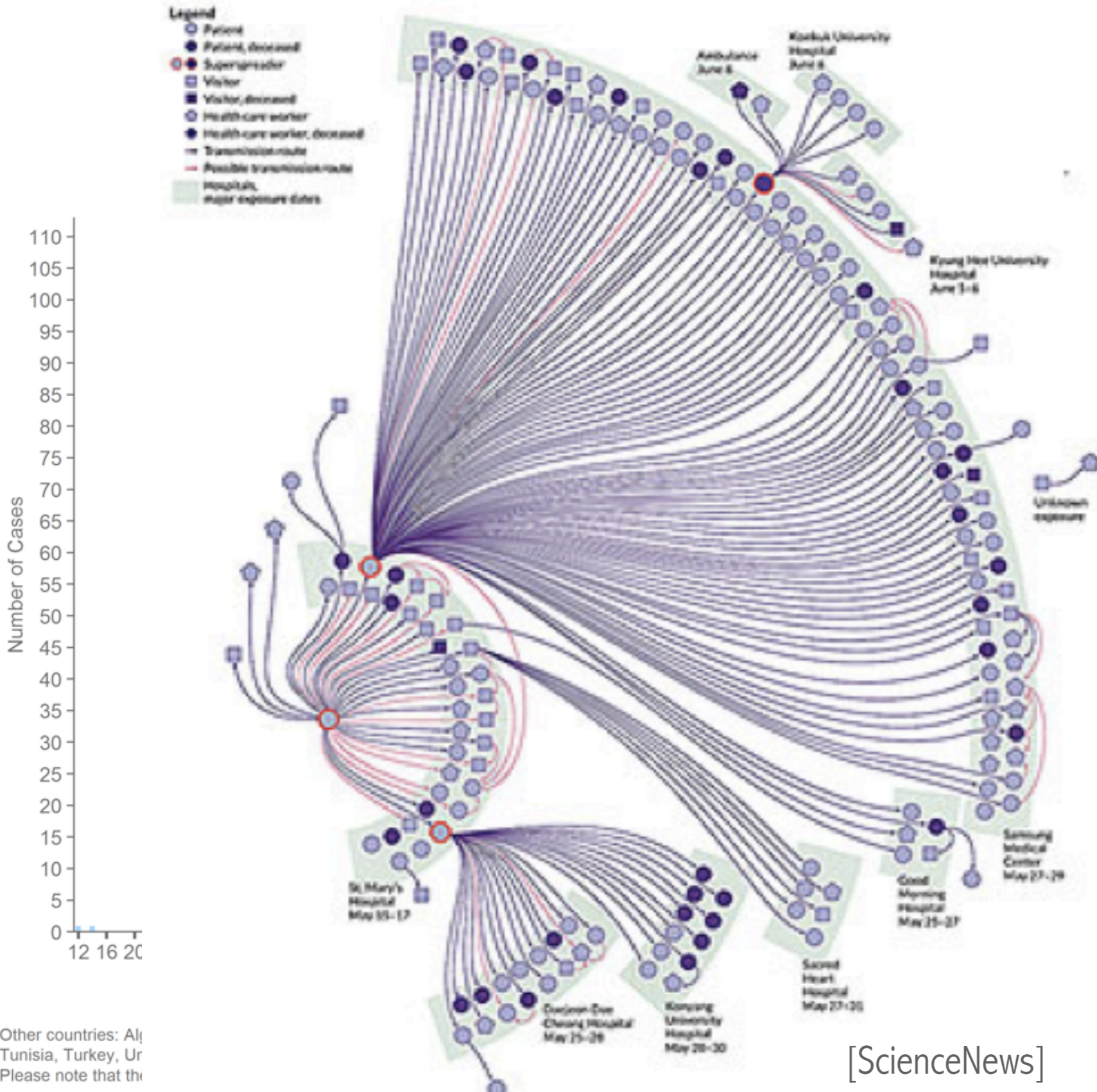
underascertainment

4-fold underascertainment
[2-6]

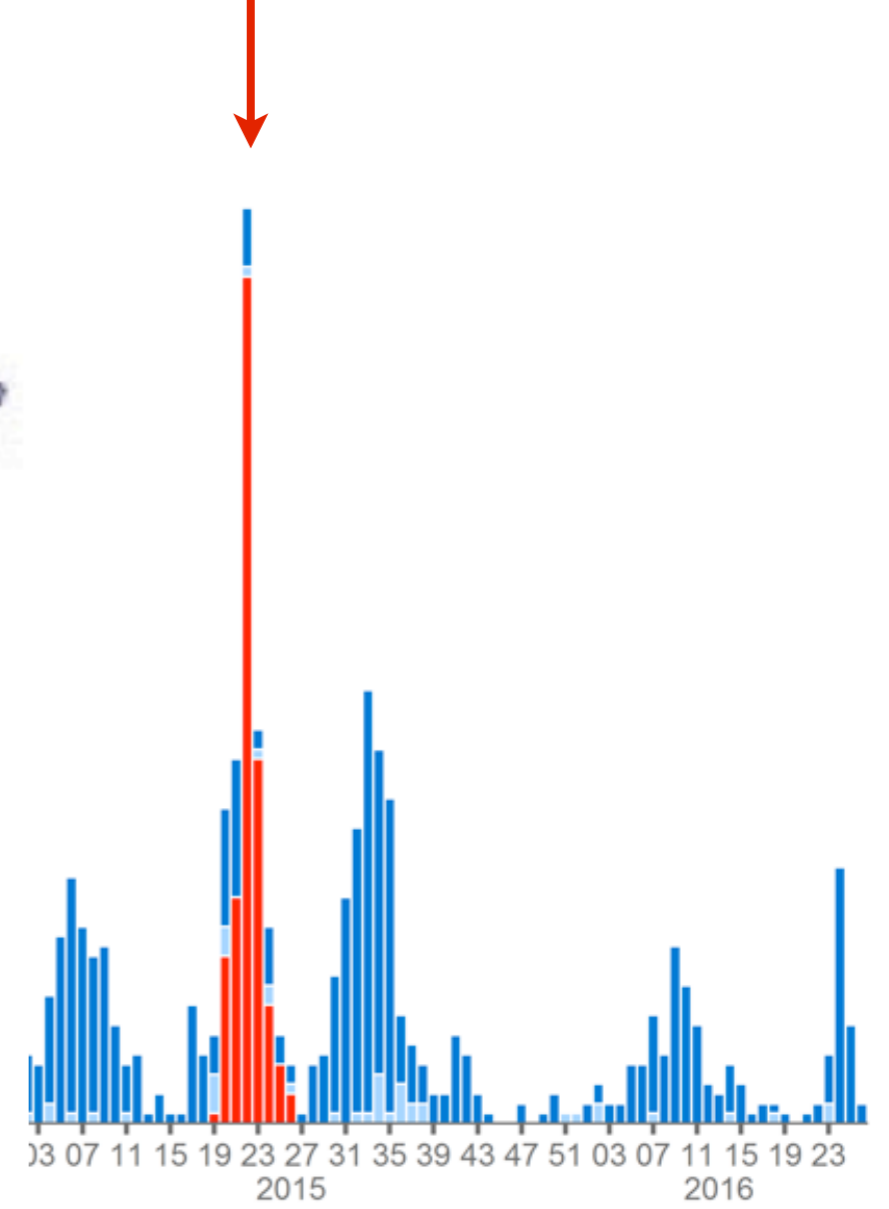


see nationwide seroprevalence investigation in SA: Muller et al 2015

Summer 2015



South Korea



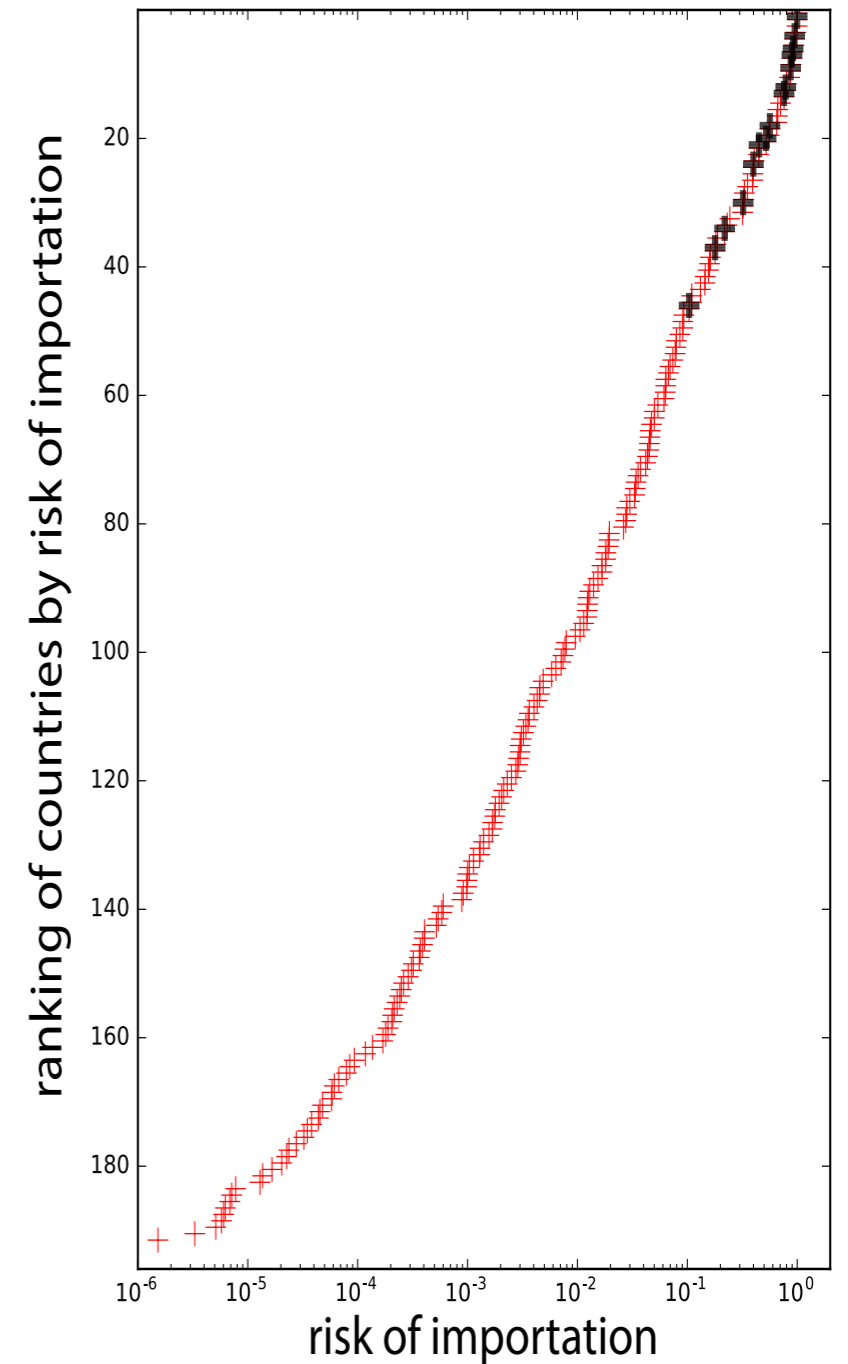
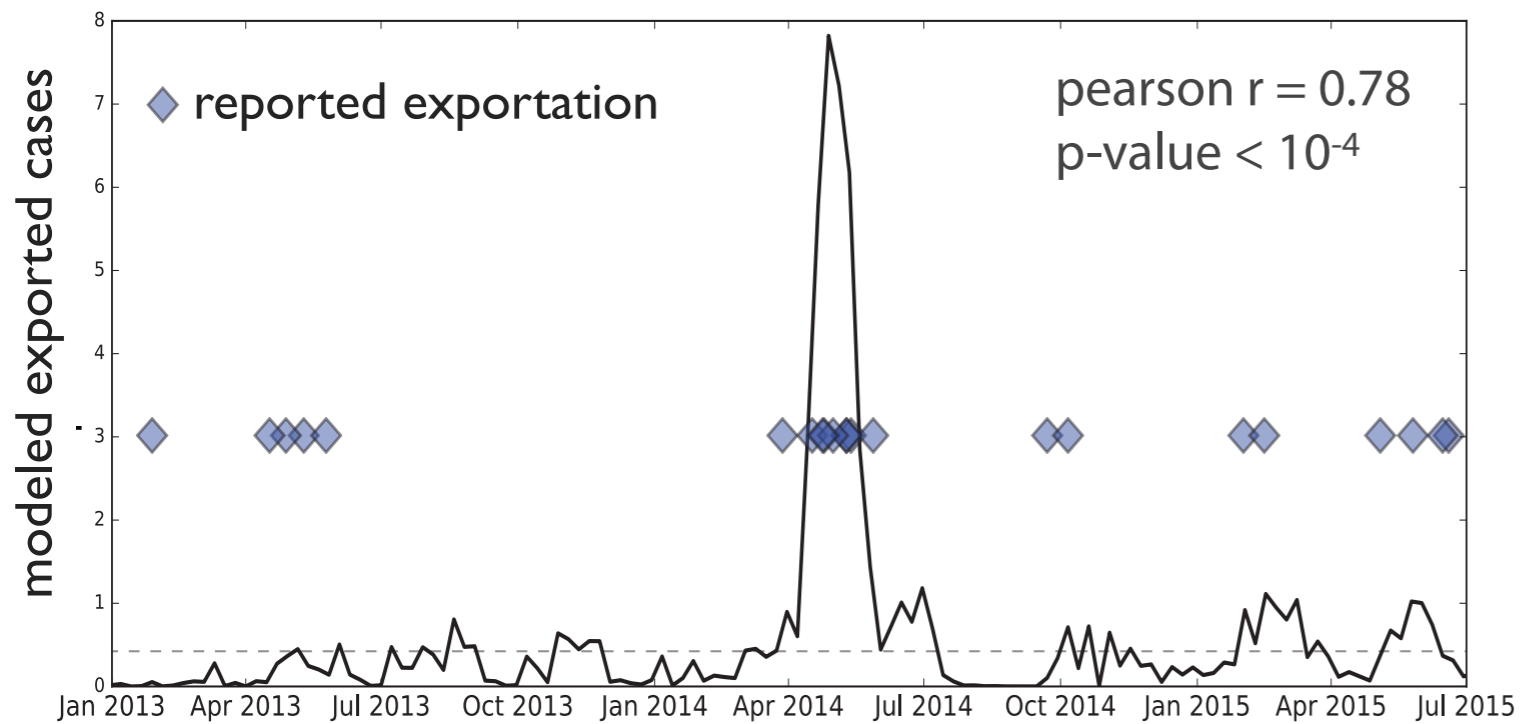
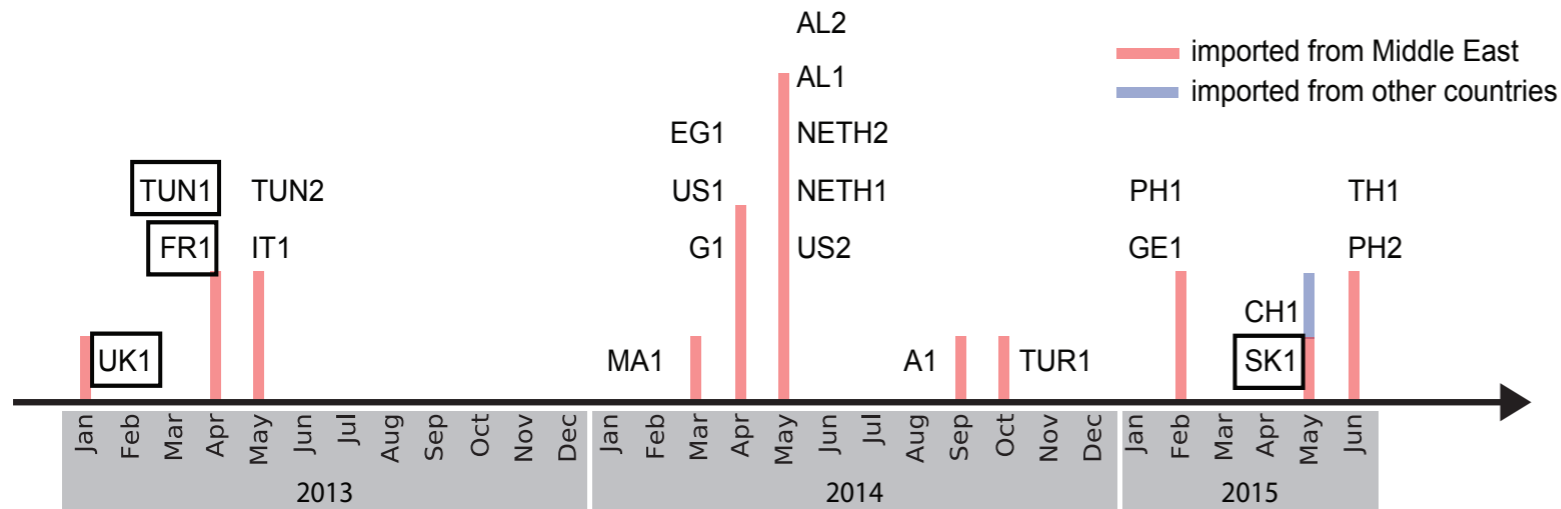
Other countries: Al
Tunisia, Turkey, Ur
Please note that th

[ScienceNews]

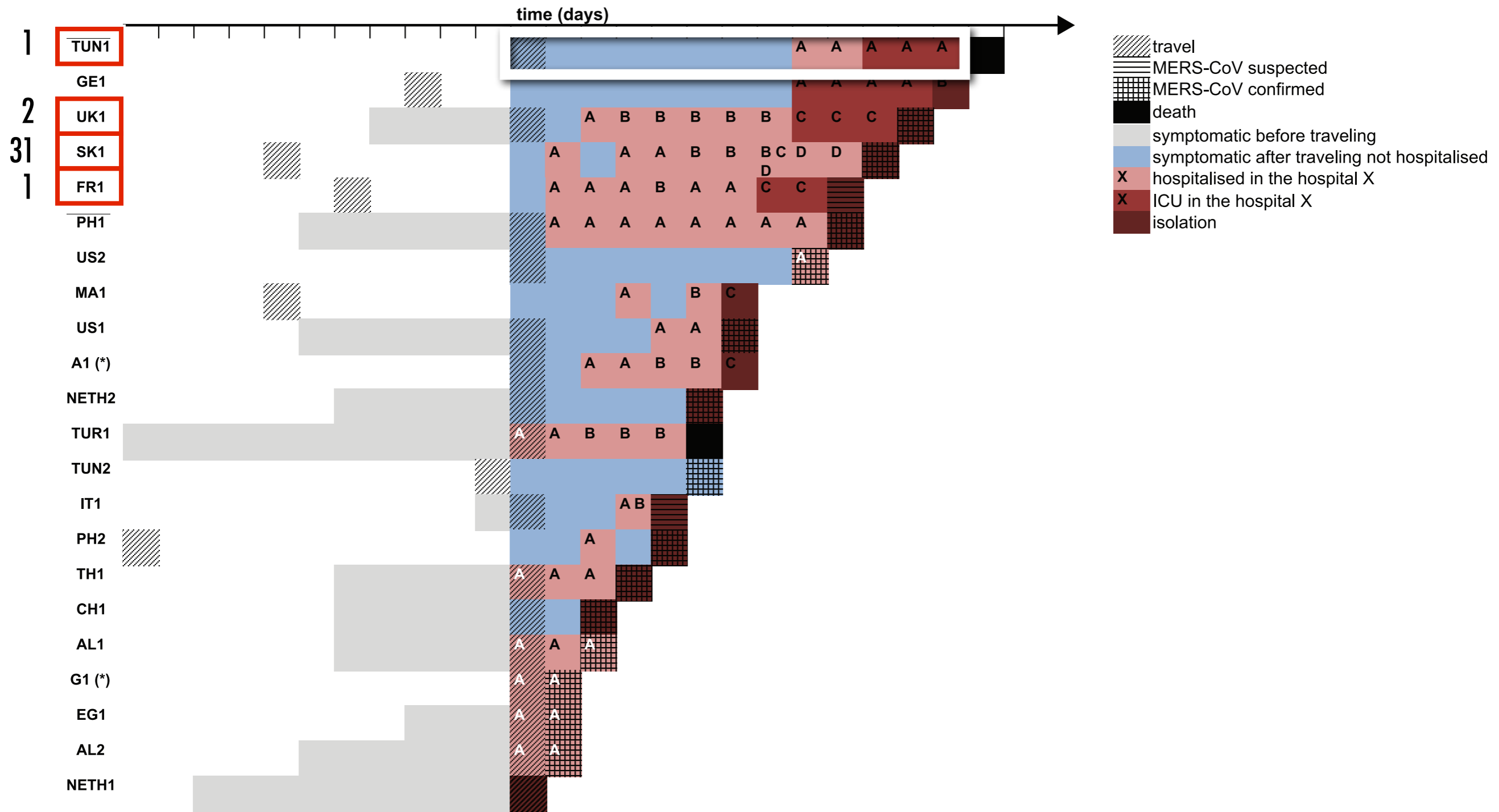
n, Philippines, Qatar, Thailand,



22 importations (2012-2015)

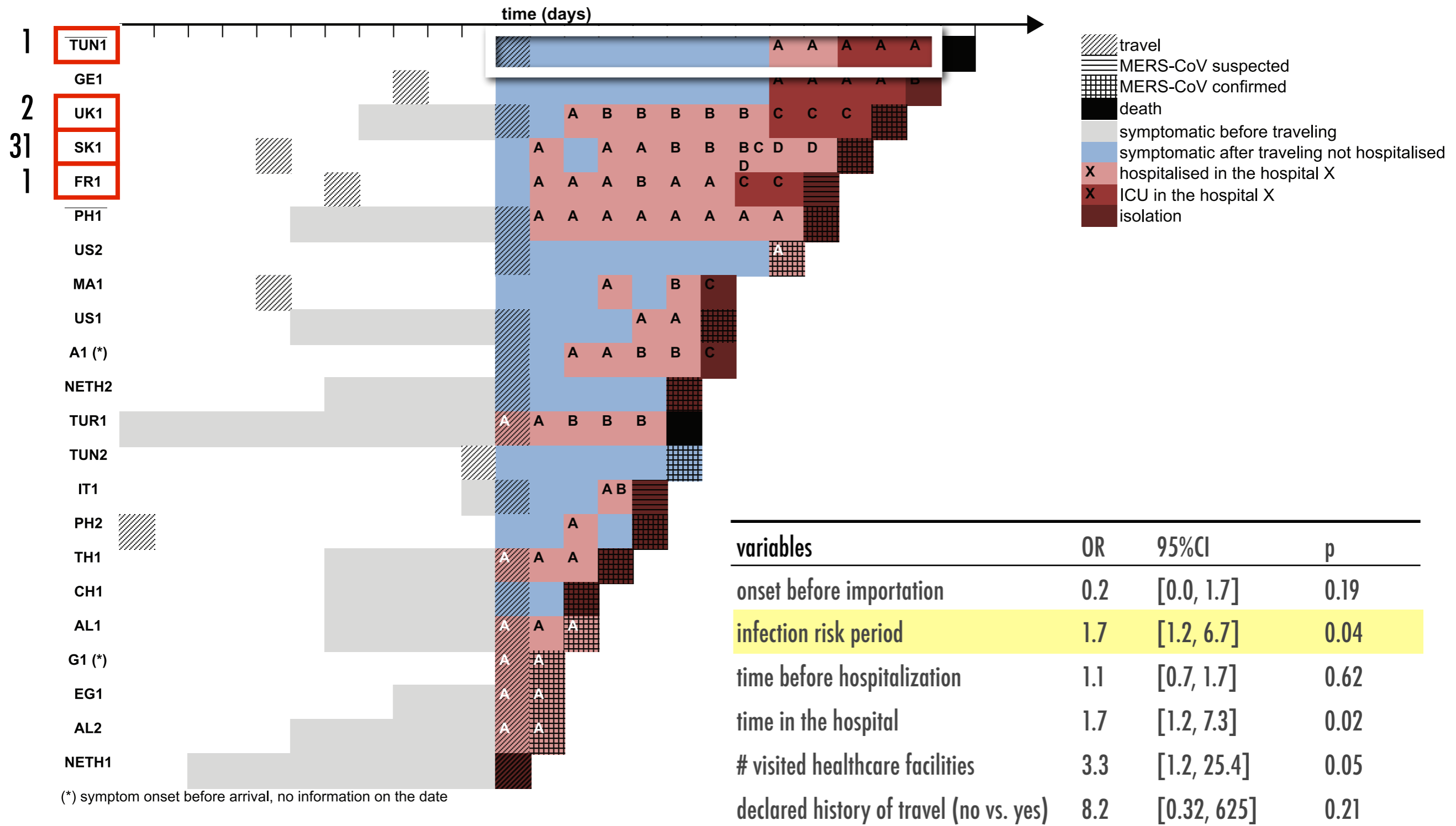


imported case history

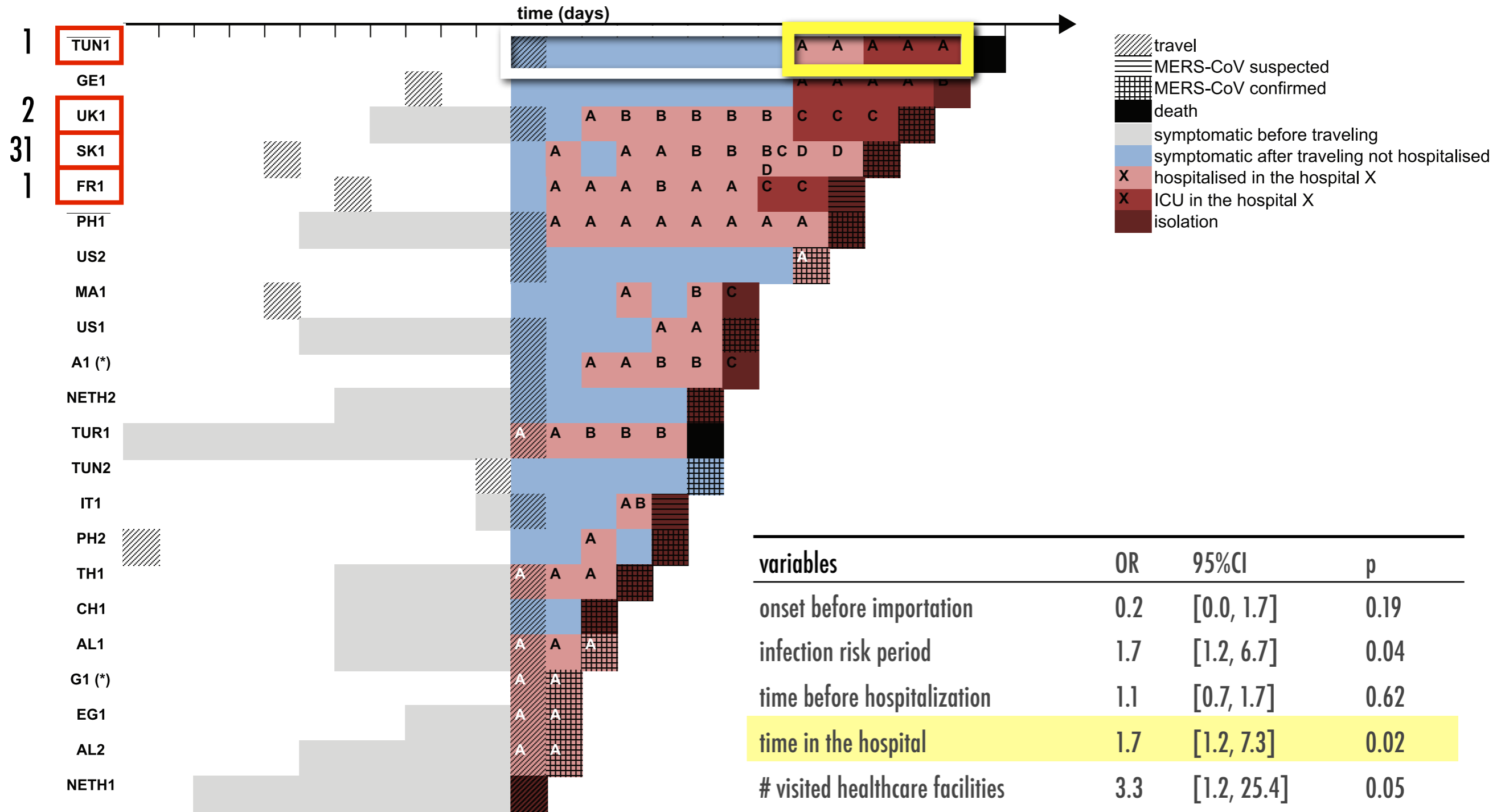


(*) symptom onset before arrival, no information on the date

risk of onward transmission



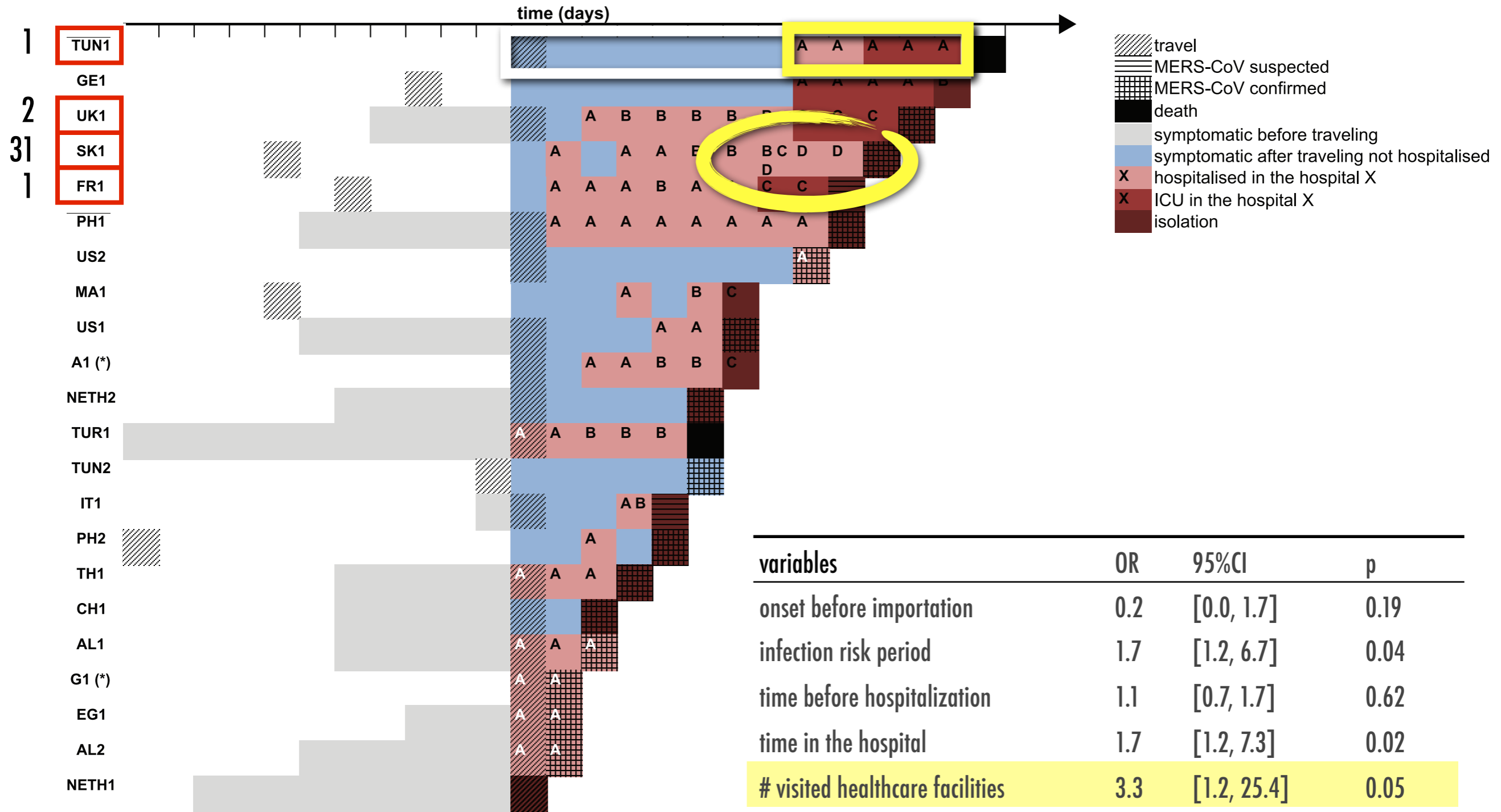
hospitalization period



(*) symptom onset before arrival, no information on the date

variables	OR	95%CI	p
onset before importation	0.2	[0.0, 1.7]	0.19
infection risk period	1.7	[1.2, 6.7]	0.04
time before hospitalization	1.1	[0.7, 1.7]	0.62
time in the hospital	1.7	[1.2, 7.3]	0.02
# visited healthcare facilities	3.3	[1.2, 25.4]	0.05
declared history of travel (no vs. yes)	8.2	[0.32, 625]	0.21

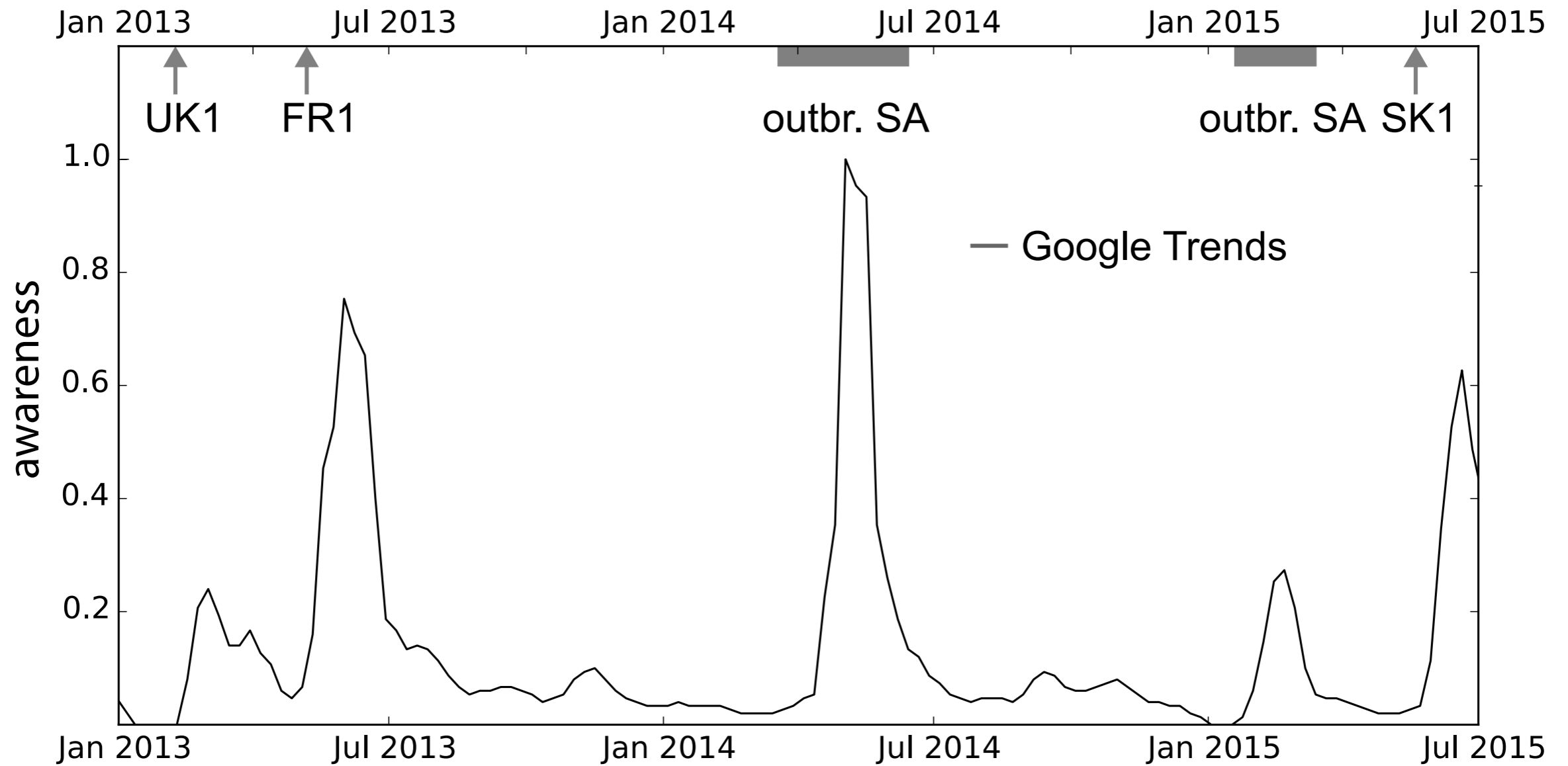
healthcare centers



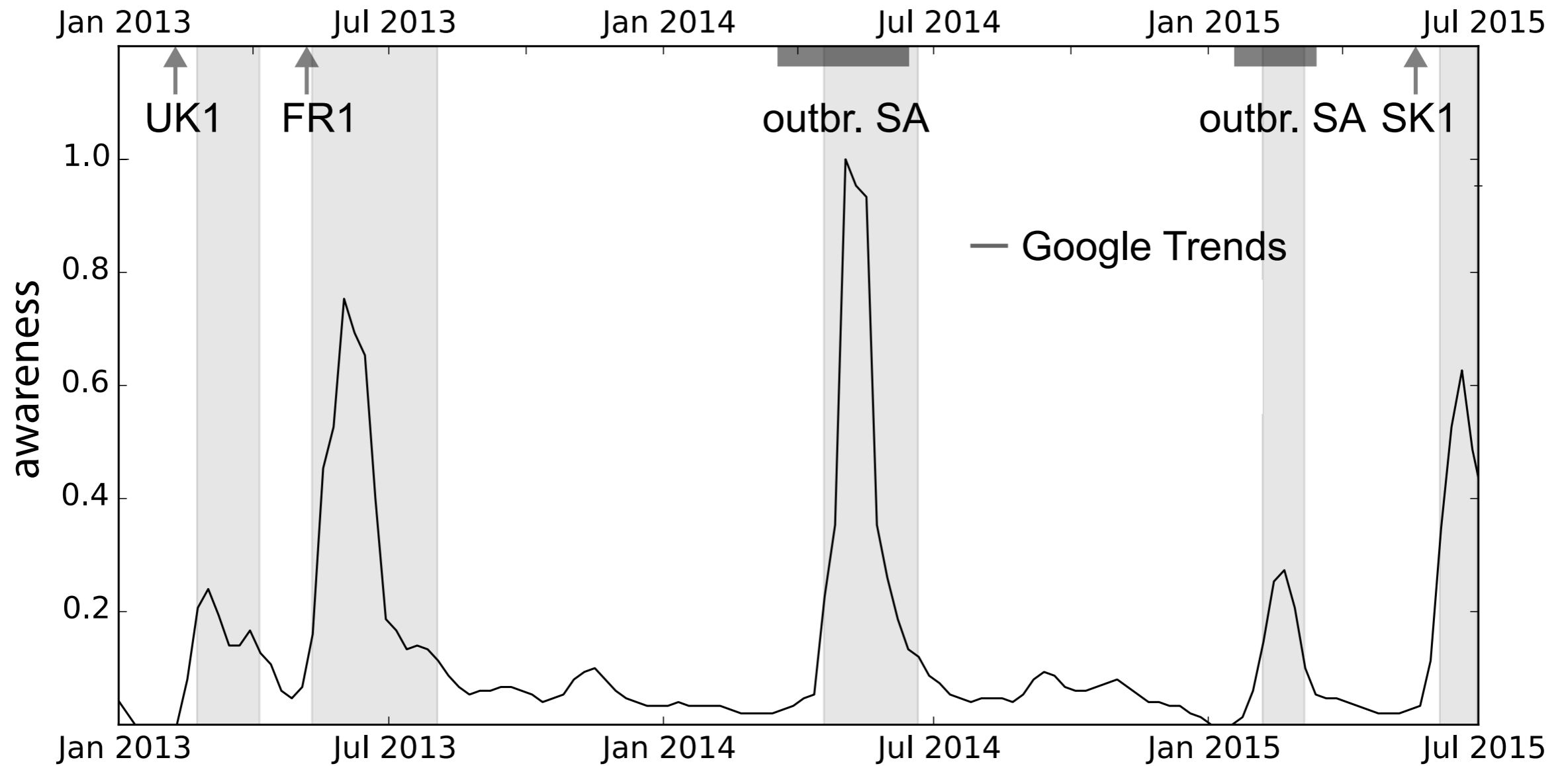
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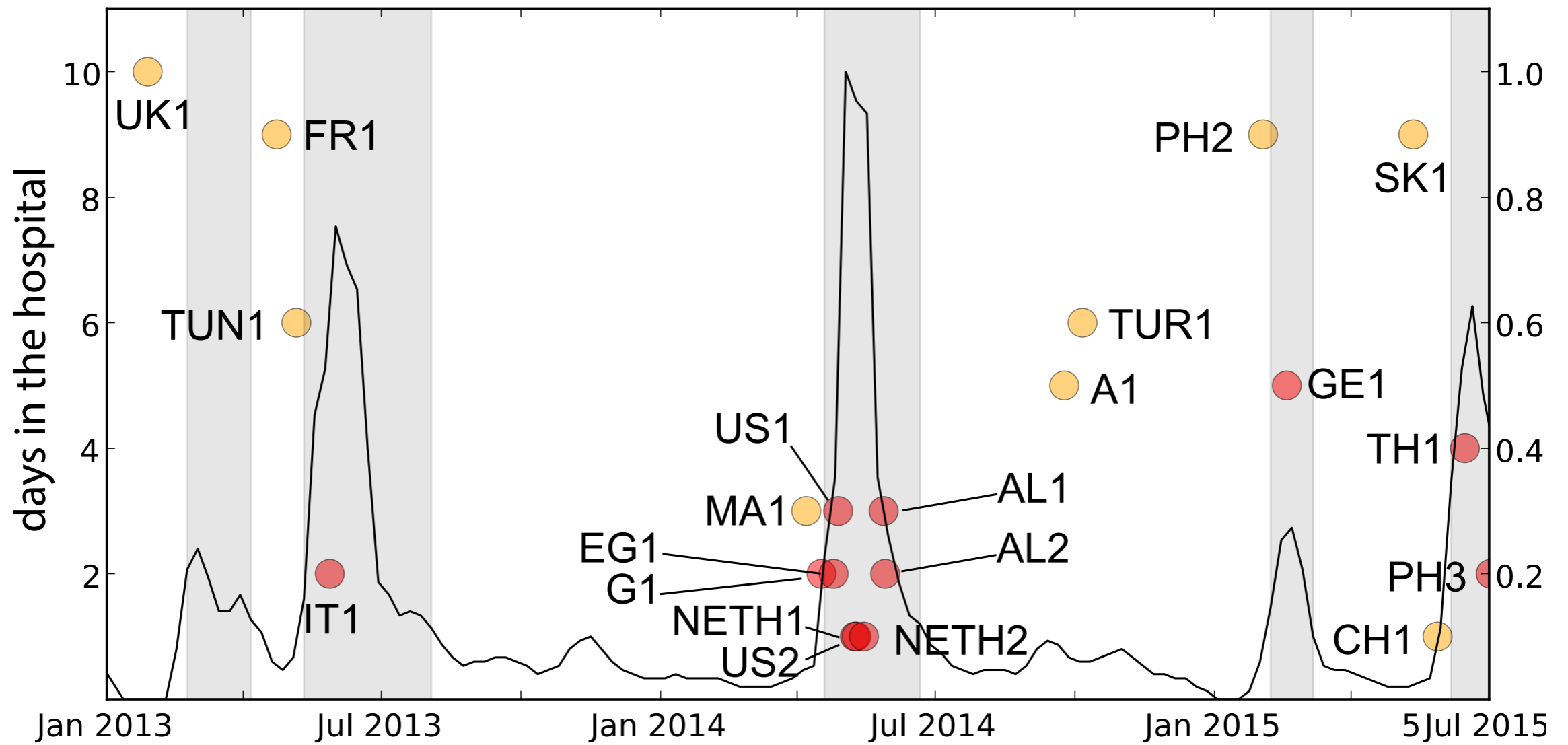
awareness



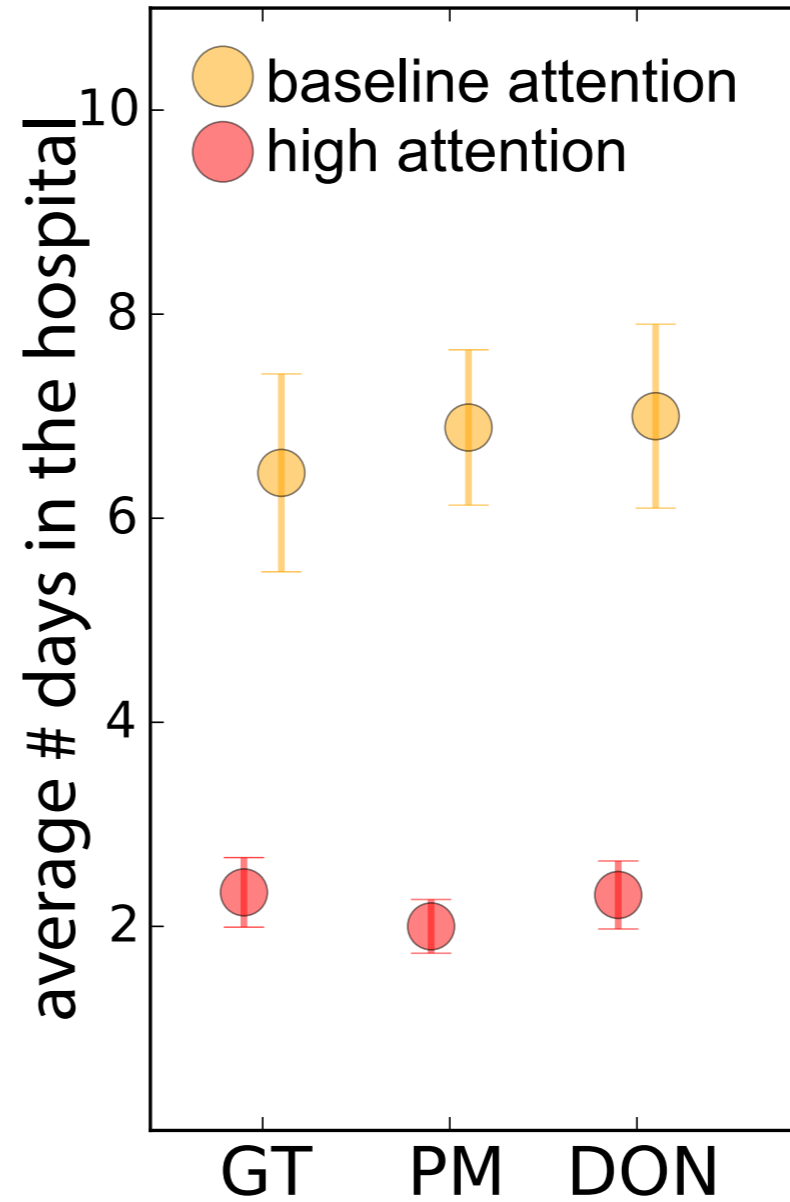
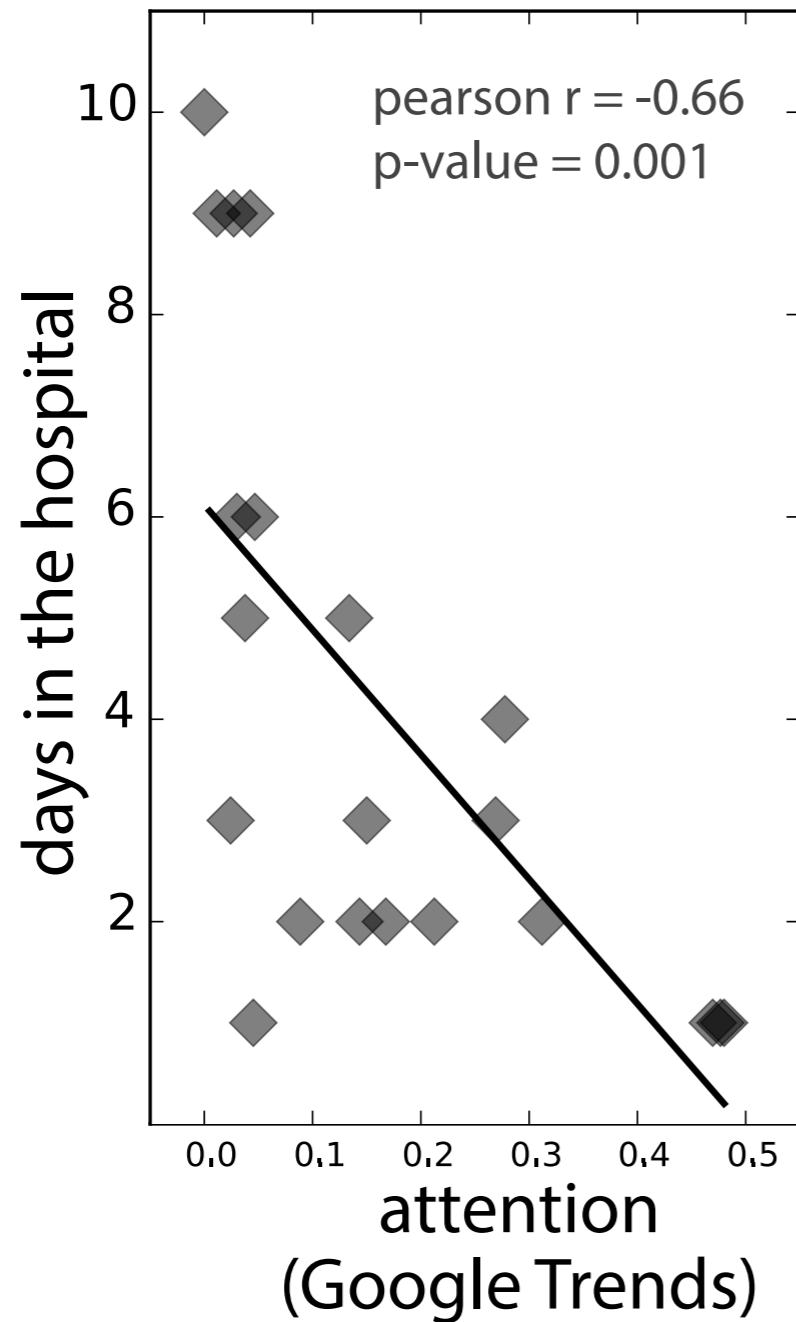
awareness



awareness vs response



awareness vs response



days in the community vs. GT:
 $r=0.22$, $p=0.32$

acknowledgments



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Poletto et al. Eurosurveillance (2014)

Poletto et al. Epidemics (2016)

doi:10.1016/j.epidem.2015.12.001

Poletto et al. under revision



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