

Estimating, evaluating, and visualizing uncertainty in the cost-effectiveness of active monitoring policies for Ebola

Nicholas G Reich, Simon Cauchemez, Justin Lessler

Epidemics 5 :: Clearwater Beach, FL :: Dec 2015



2014-15 West Africa Ebola outbreak (as of 25 Nov 2015)

Country	Cumulative cases	Cases in past 21 days	Cumulative deaths
Guinea	3,804	0	2,536
Liberia	10,675	3	4,808
Sierra Leone	14,122	0	3,955
Total	28,601	3	11,299

data source: http://apps.who.int/iris/bitstream/10665/197915/1/ebolasitrep_25Nov2015_eng.pdf?ua=1&ua=1



Texas nurse who had worn protective gear tests positive for Ebola

By Elizabeth Cohen, Steve Almasy and Holly Yan, CNN

⌚ Updated 7:12 AM ET, Mon October 13, 2014

NEWS

NEW YORK POST

Doctor who treated Ebola patients rushed to NYC hospital

By Jamie Schram, Frank Rosario and Shawn Cohen

October 23, 2014 | 2:44pm

The New York Times

Ebola Infects Spanish Nurse, a First in West

By RAPHAEL MINDER and DENISE GRADY OCT. 6, 2014

2014-15 West Africa Ebola outbreak (as of 25 Nov 2015)

Country	Cumulative cases	Cases in past 21 days	Cumulative deaths
USA	4	0	1
UK	1	0	0
Italy	1	0	0
Spain	1	0	0
Total	7	0	1

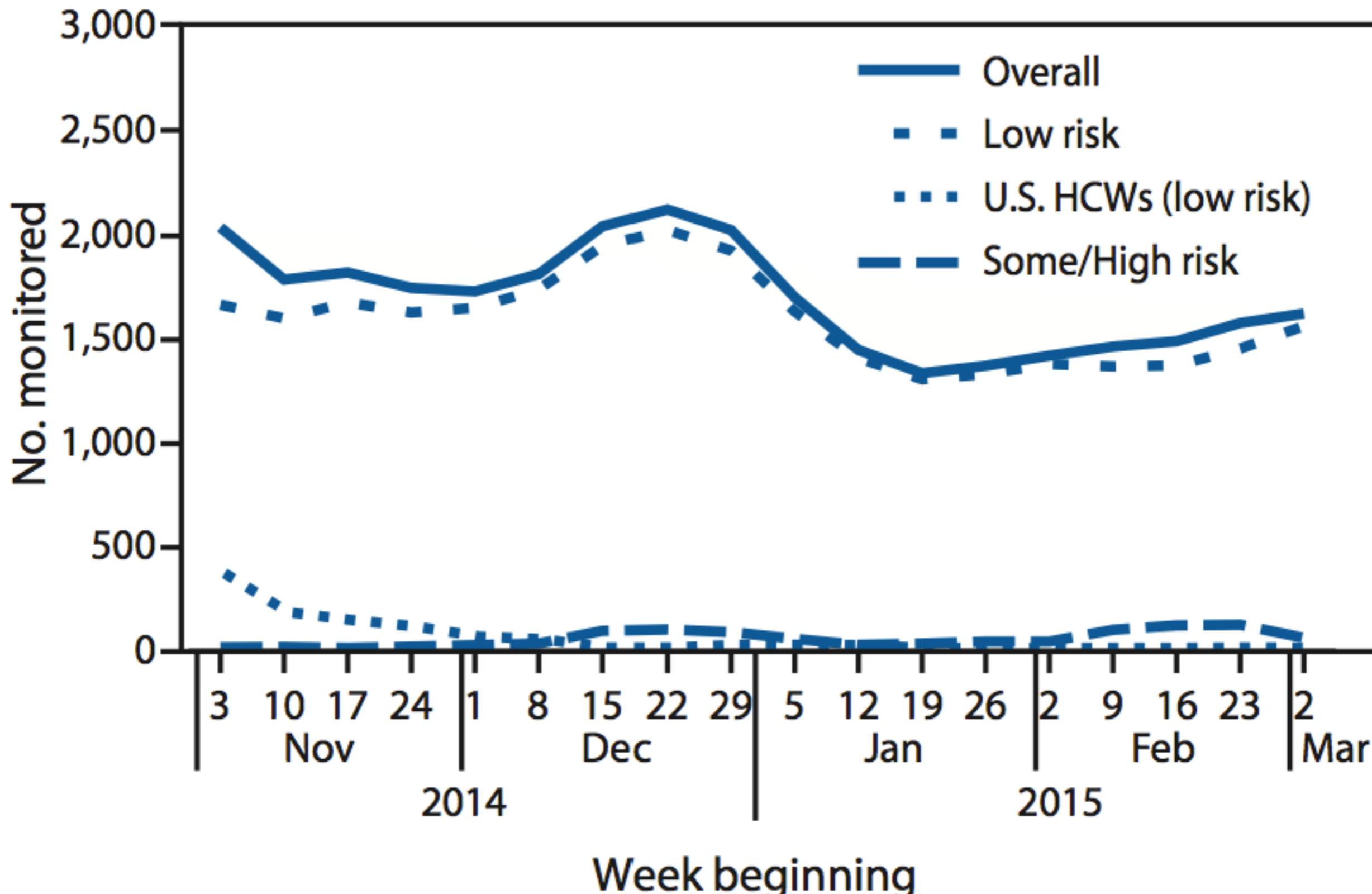
data source: <http://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/case-counts.html>

Ebola (Ebola Virus Disease)

Interim U.S. Guidance for Monitoring and Movement of Persons with Potential Ebola Virus Exposure

Updated: October 9, 2015

“Active monitoring means that the state or local public health authority assumes responsibility for establishing regular communication with potentially exposed people, including checking daily to assess for the presence of symptoms and fever, rather than relying solely on people to self-monitor (check themselves for fever and other symptoms) and report symptoms if they develop.”

Monitoring of Persons with Risk for Exposure to Ebola Virus Disease —
United States, November 3, 2014–March 8, 2015Tasha Stehling-Ariza, PhD^{1,2}; Emily Fisher, MD^{1,3}; Sara Vagi, PhD²; Ethan Fechter-Leggett, DVM^{1,4}; Natasha Prudent, MPH²; Mary Dott, MD²; Randolph Daley, DVM²; Rachel Nonkin Avchen, PhD² (Author affiliations at end of text)

Ebola Crisis Passes, but Questions on Quarantines Persist

By SHERI FINK DEC. 2, 2015

“[S]tates, which have the legal authority to impose quarantines, often exceeded [CDC] guidelines, restricting the movements of returning health workers and others.

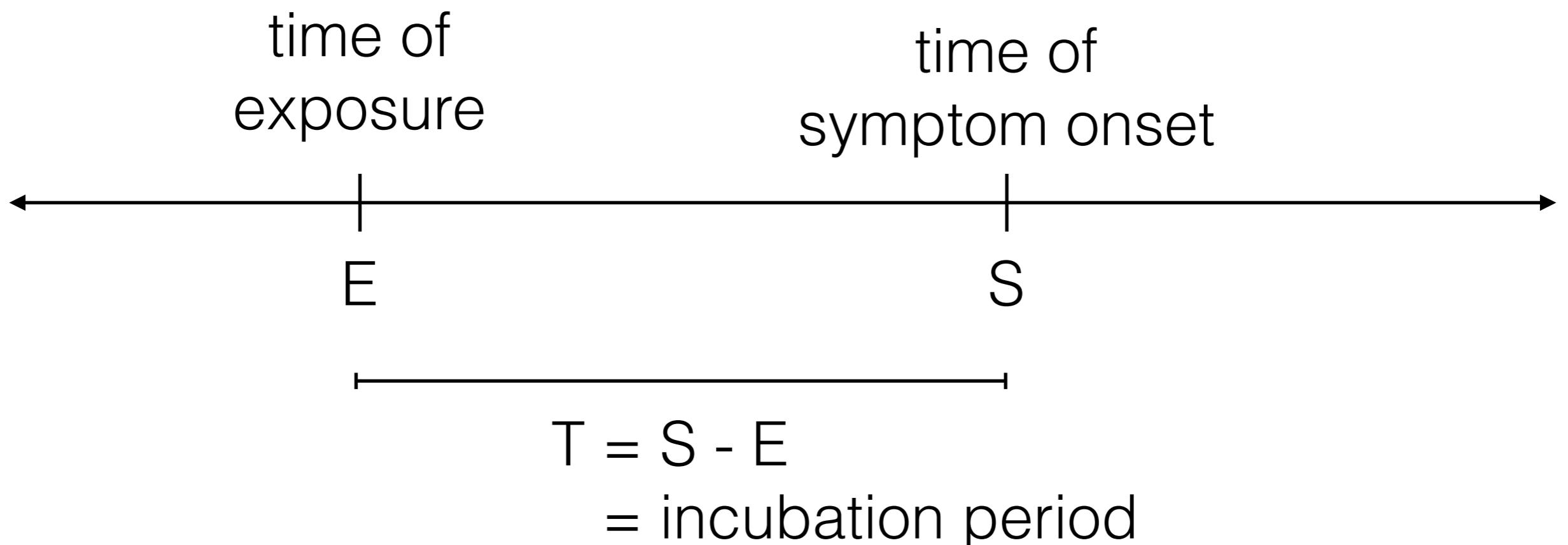
...

In interviews and in the new report, legal experts questioned the legality and even the constitutionality of quarantines in these situations. “The state has to have **clear and convincing evidence** that the detention is necessary to prevent the spread of disease,” said Wendy Parmet, director of the program on health policy and law at Northeastern University. ...”

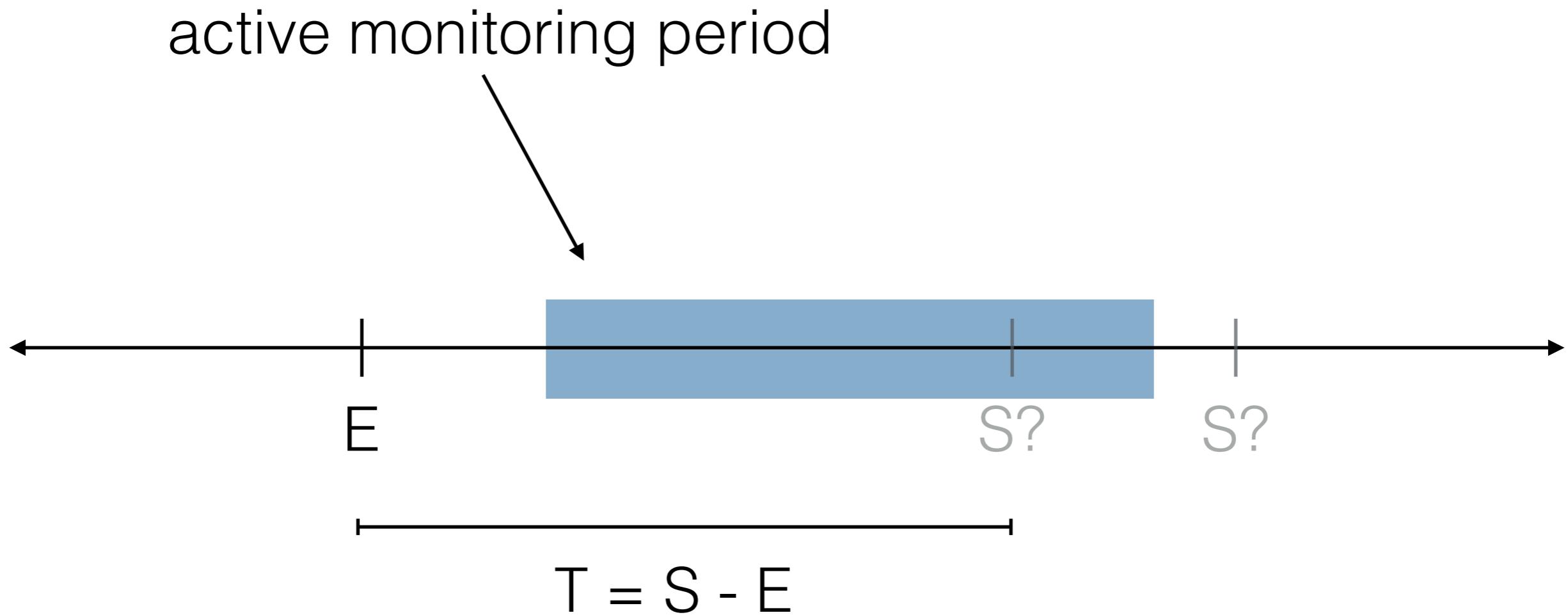
How long should
active monitoring last?

Can we use data to help
guide this decision making?

the incubation period



Relation of incubation period to active monitoring



The incubation period distribution determines the probability of a case being missed by active monitoring.



Articles

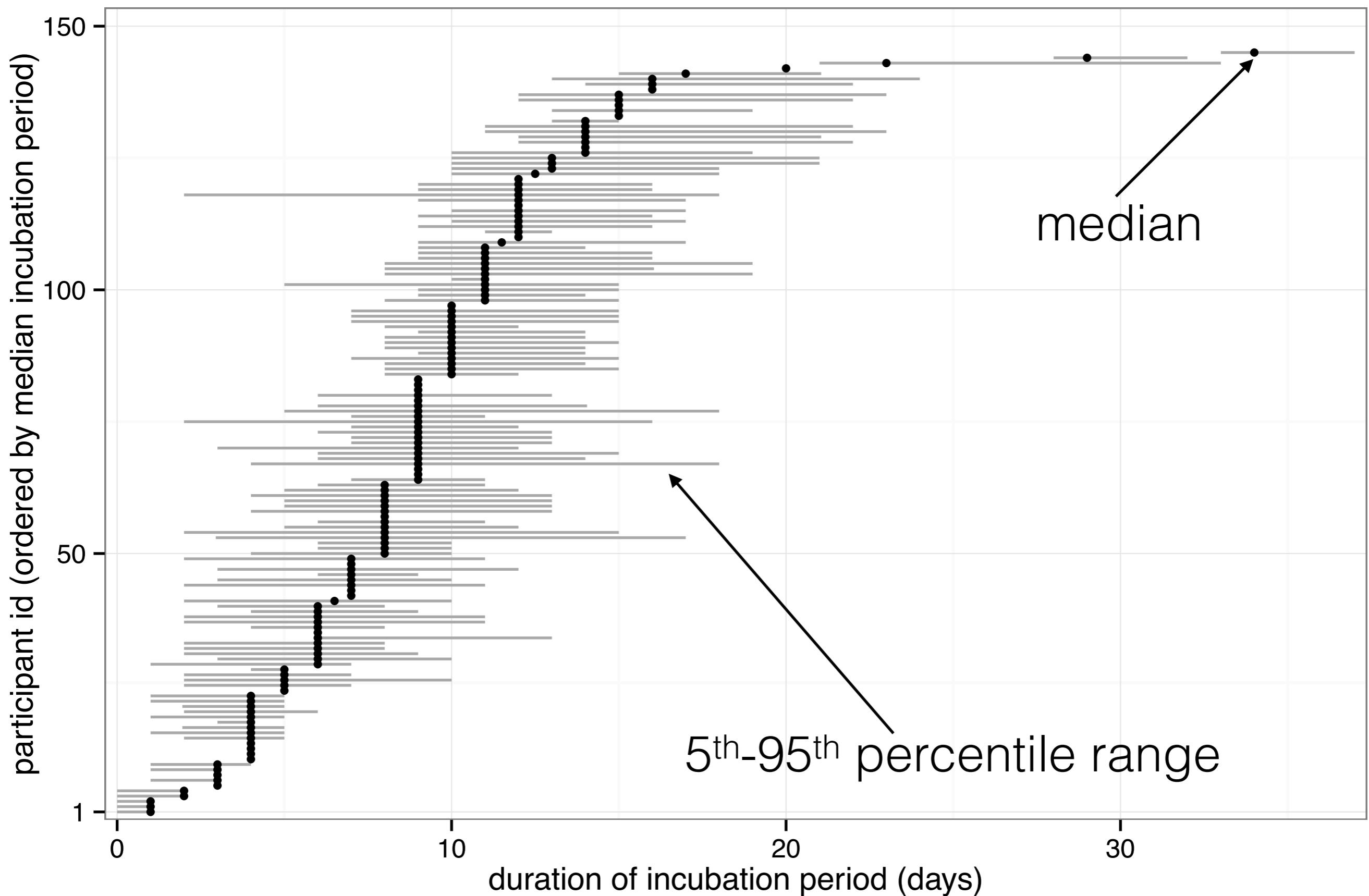
Chains of transmission and control of Ebola virus disease in Conakry, Guinea, in 2014: an observational study

Ousmane Faye, Pierre-Yves Boëlle*, Emmanuel Heleze, Oumar Faye, Cheikh Loucoubar, N’Faly Magassouba, Barré Soropogui, Sakoba Keita, Tata Gakou, El Hadji Ibrahima Bah, Lamine Koivogui, Amadou Alpha Sall†, Simon Cauchemez‡*

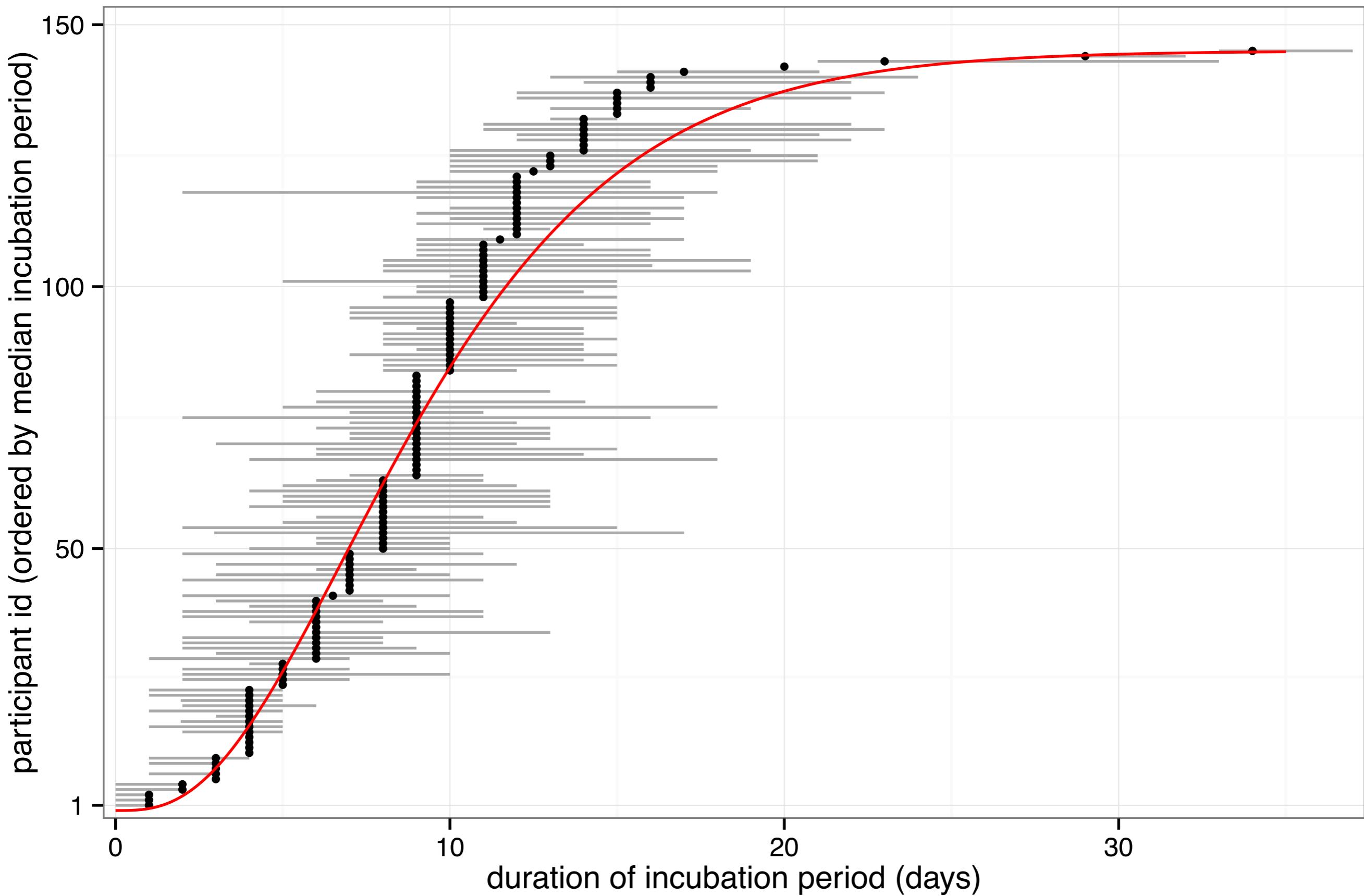
“Similar to results of other investigators, we estimated the mean incubation period to be 9·9 (9·0–11·0 days [SD 5·5, 95% CI 4·7–6·5])...”

We need a higher resolution estimate of the incubation period distribution.

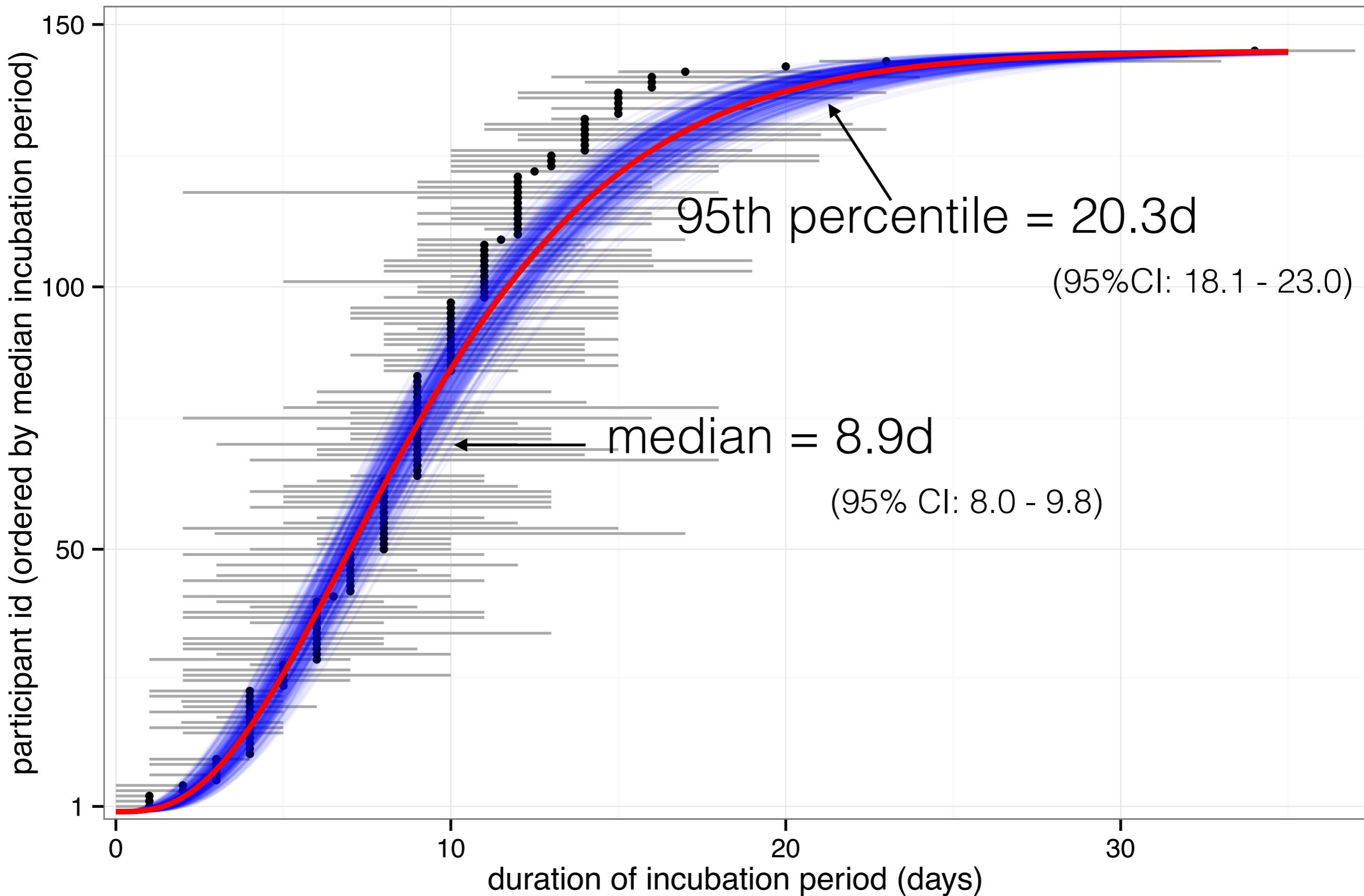
Samples of incubation periods from Faye et al.



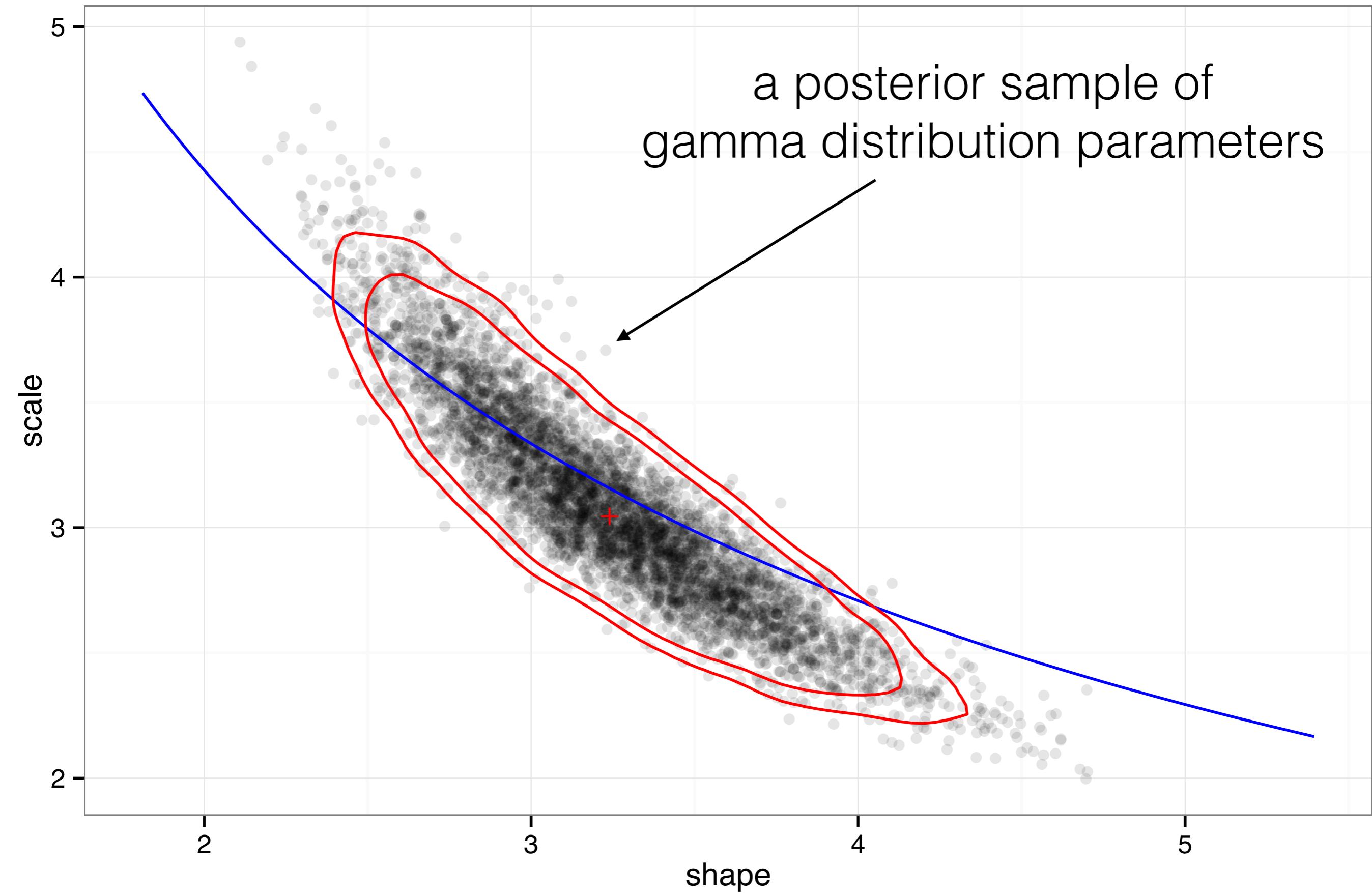
Fitted Gamma distribution to data from Faye et al.

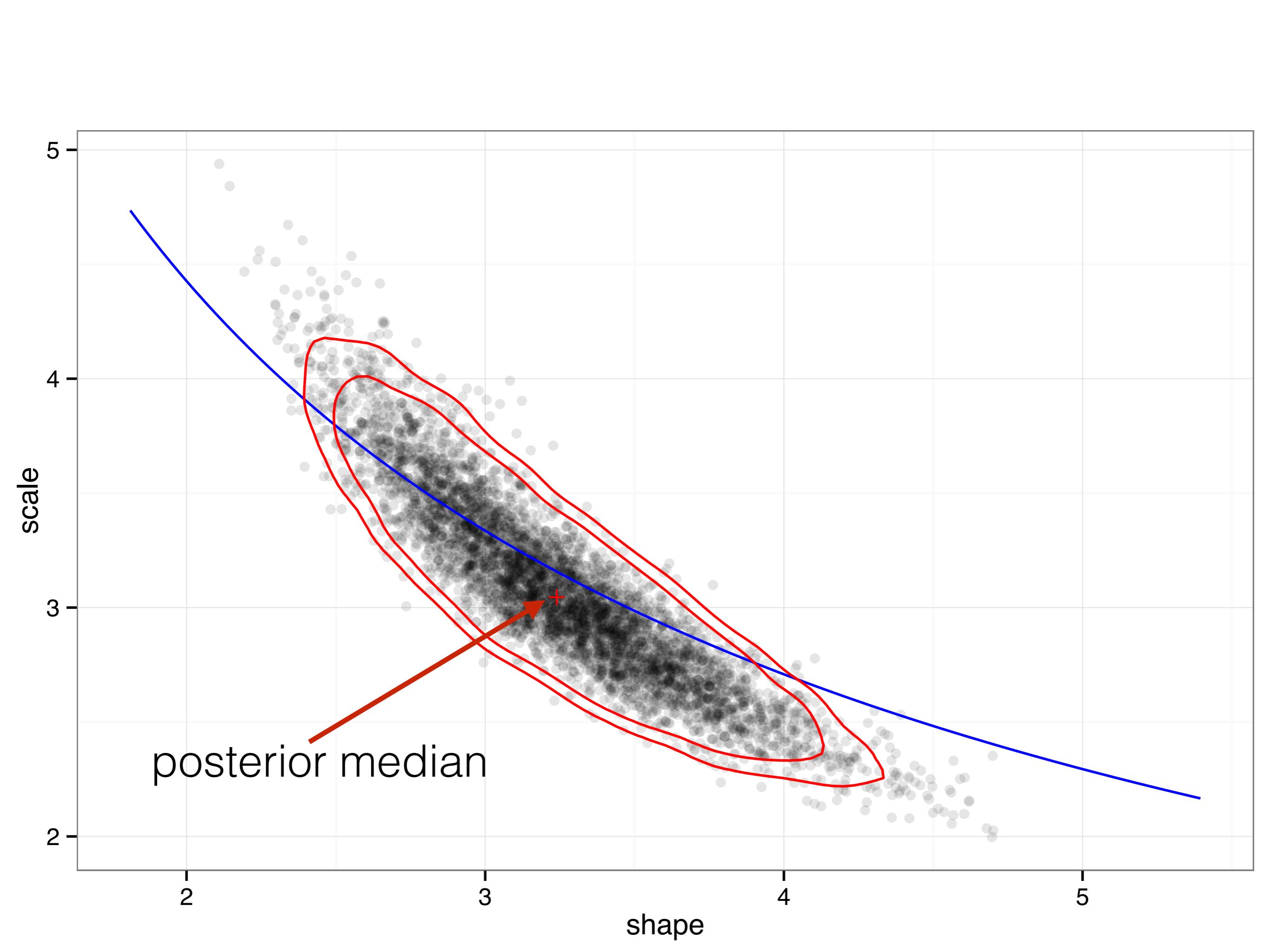


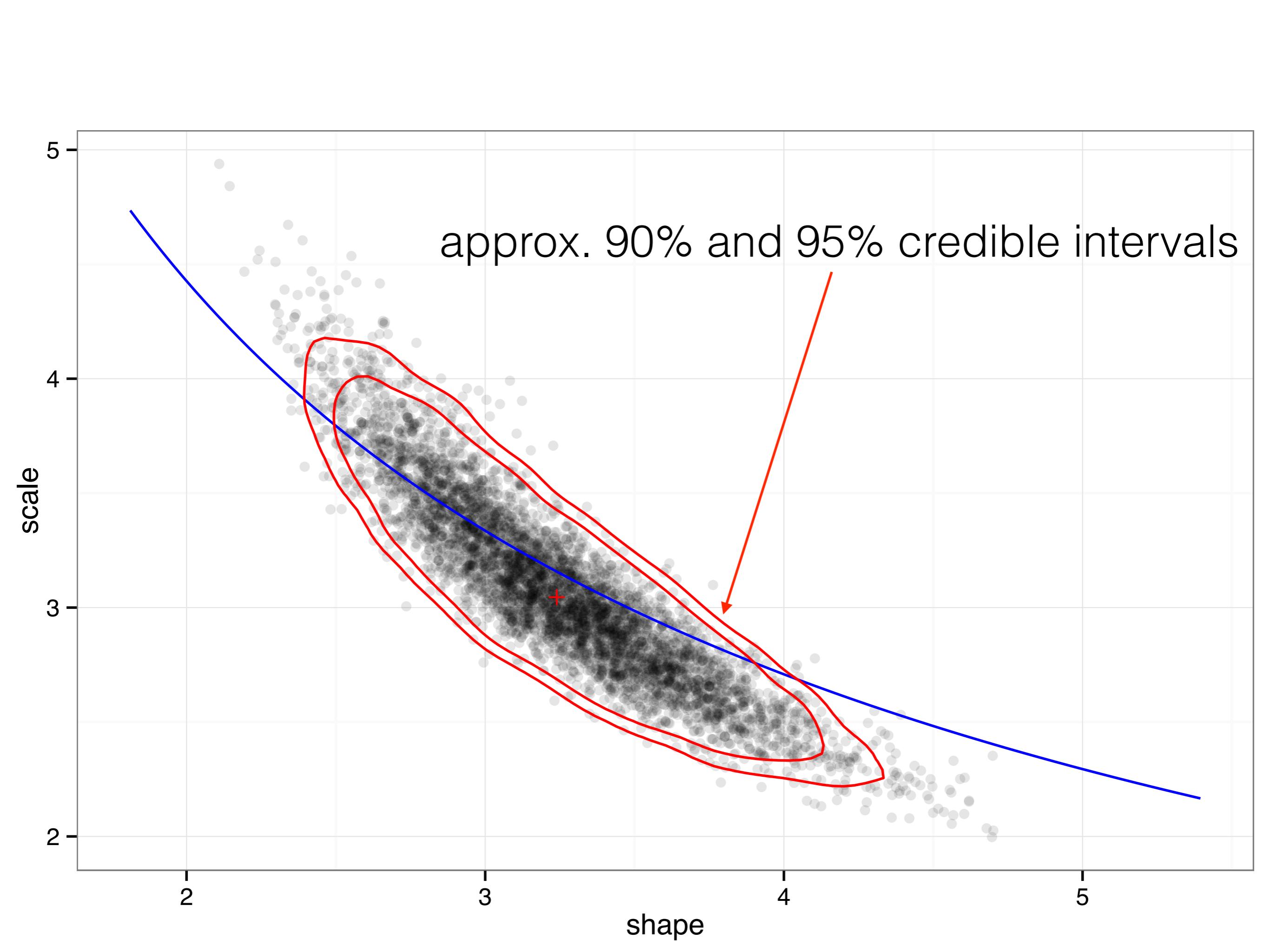
Fitted Gamma distribution to data from Faye et al.

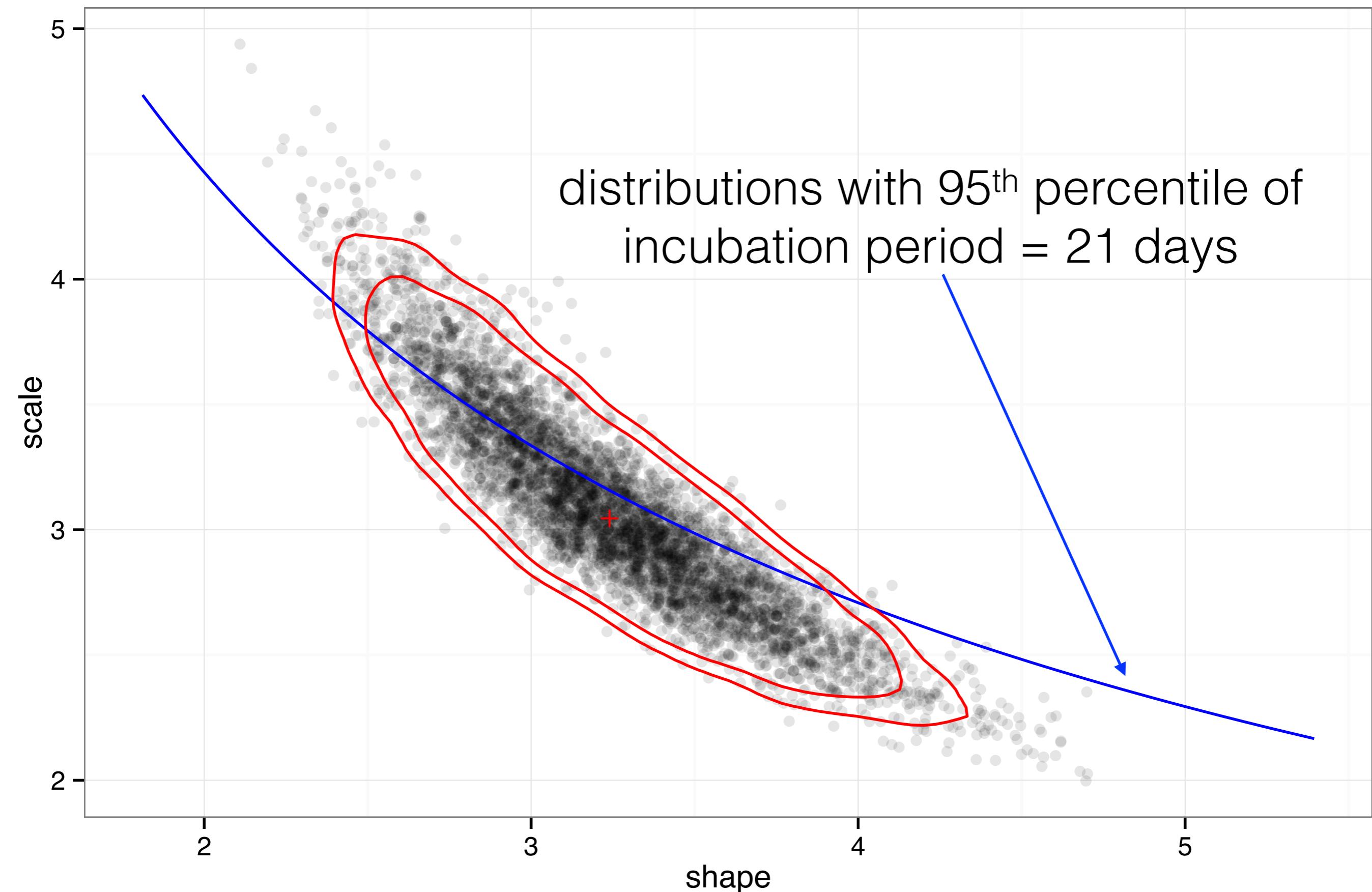


a posterior sample of
gamma distribution parameters









What is the probability that the active monitoring period will catch symptomatic individuals?

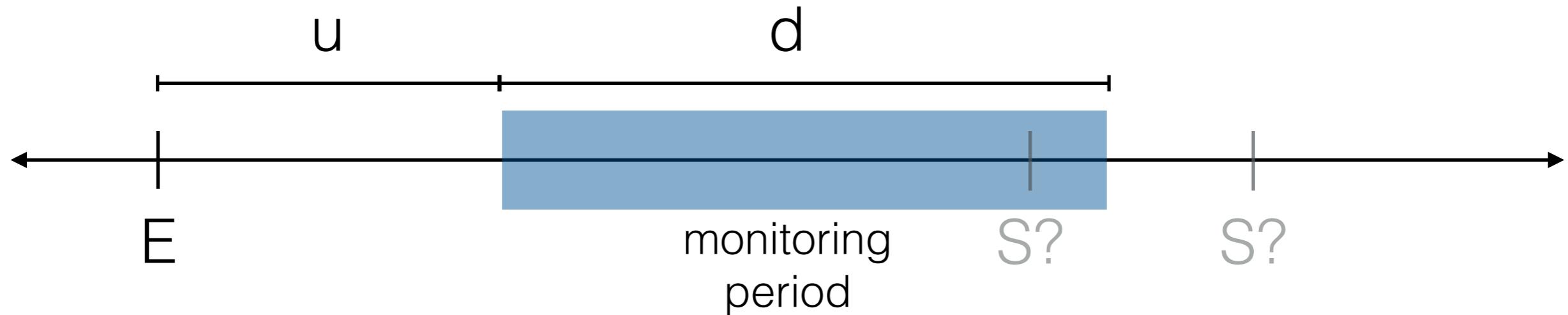
Parameters of an active monitoring system

ϕ = the probability of developing symptomatic illness

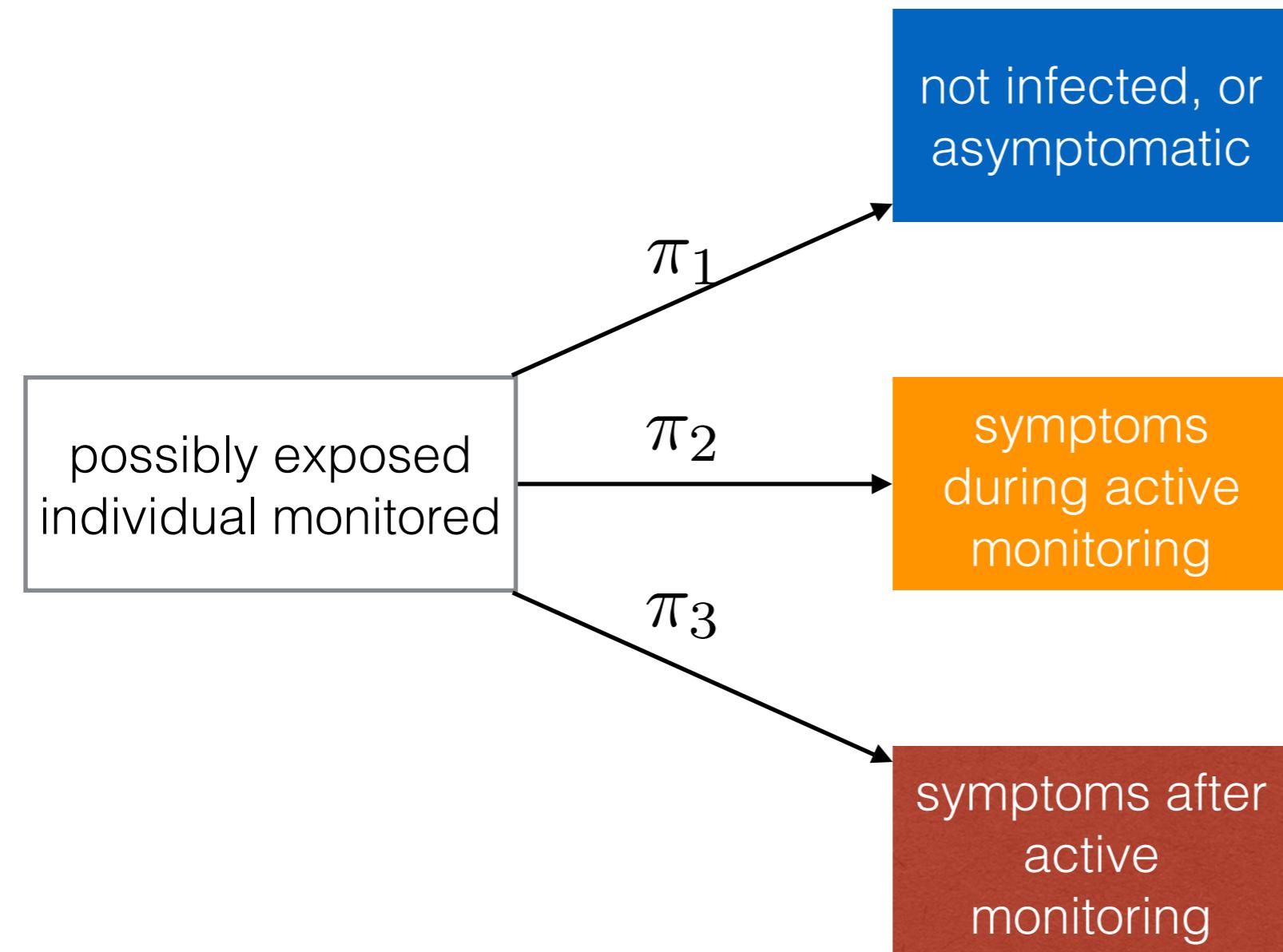
d = duration of active monitoring

u = assumed duration between exposure and active monitoring

For an individual who will develop symptoms:



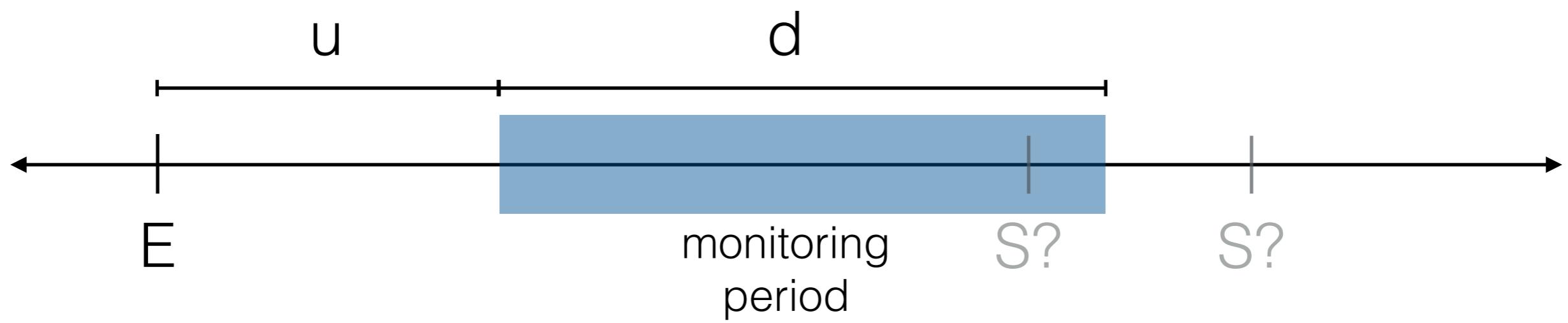
probabilities



$$\pi_1 = 1 - \phi$$

$$\pi_2 = \phi \cdot \Pr(T \leq d + u)$$

$$\pi_3 = \phi \cdot \Pr(T > d + u)$$

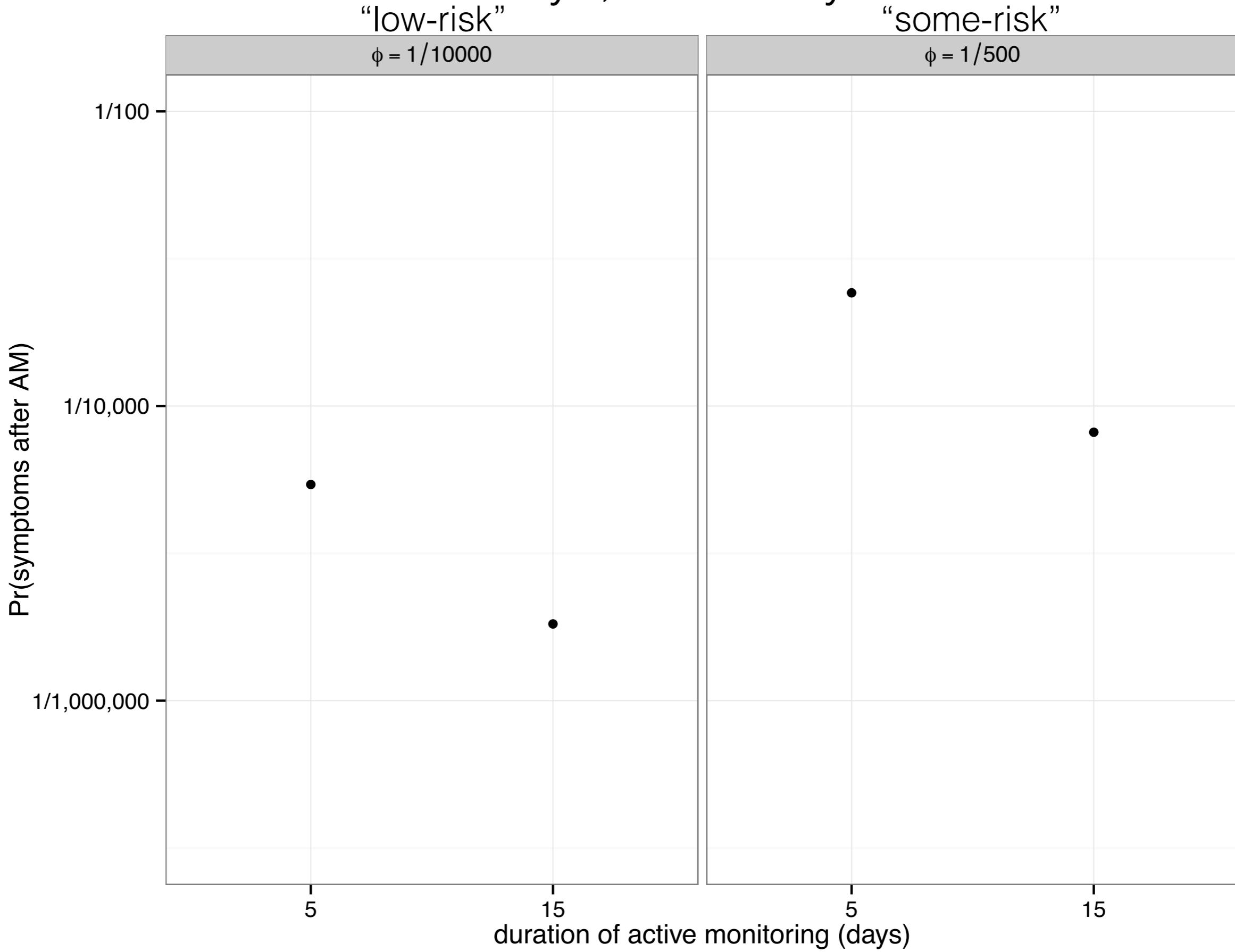


Example risk scenarios

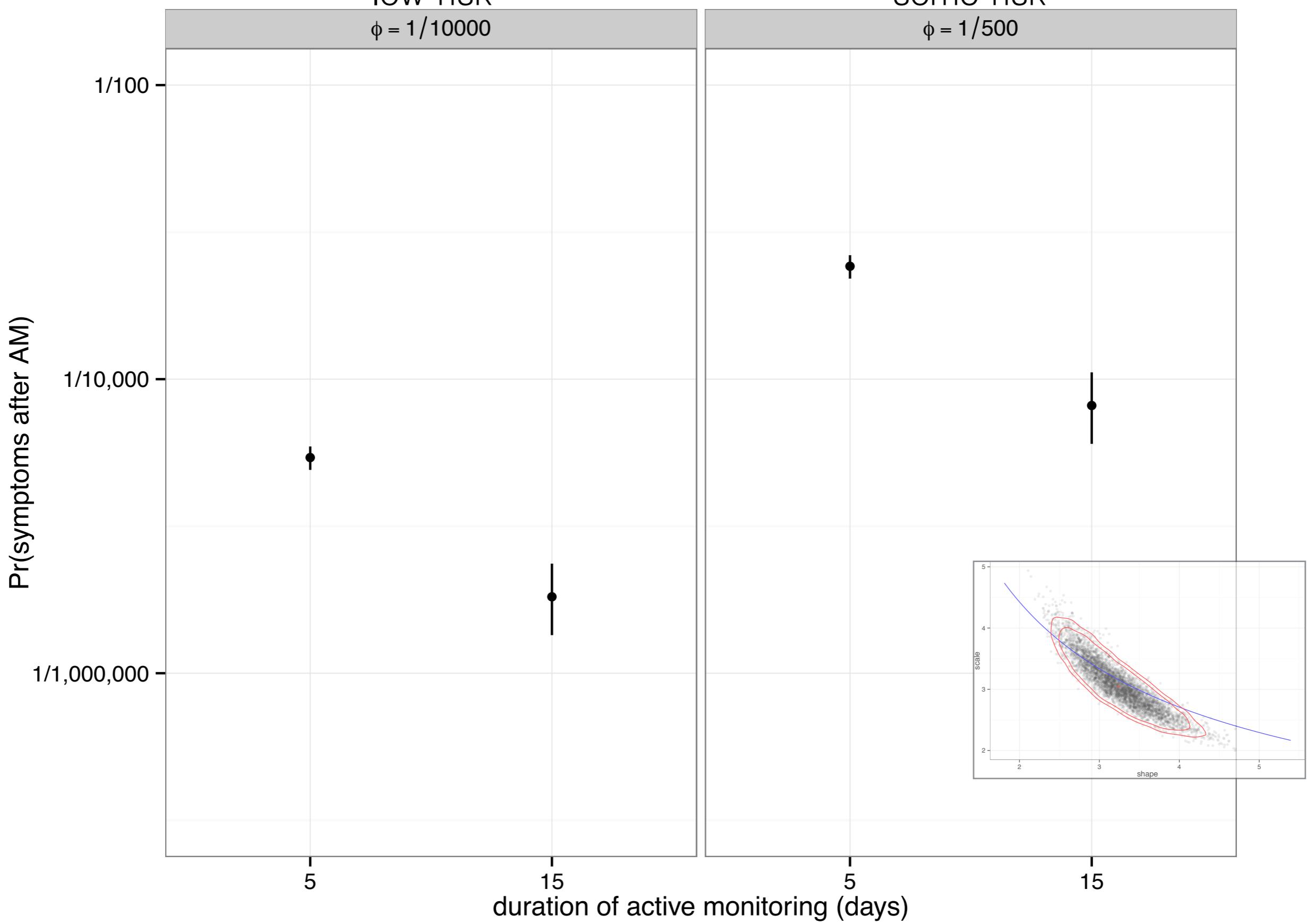
	Scenario A	Scenario B
CDC risk level	"low-risk"	"some-risk"
monitored individual	traveller visited country with widespread Ebola transmission	volunteer clinician worked in Ebola treatment center, using appropriate PPE
approx. $\Pr(\text{infection}), \phi$	1/10,000	1/500

Estimated probability of symptoms during active monitoring

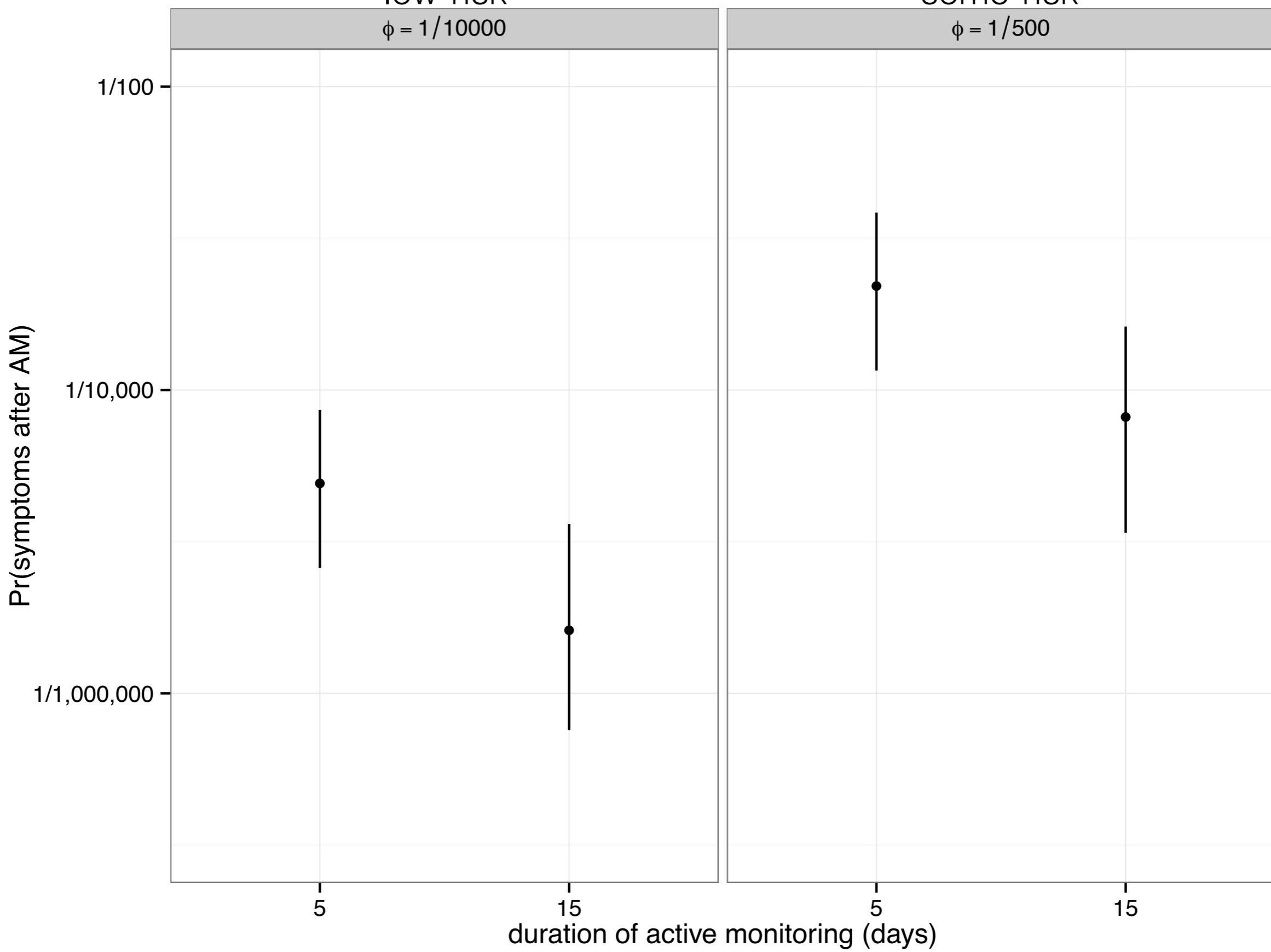
$u=7$ days, $d=15$ days



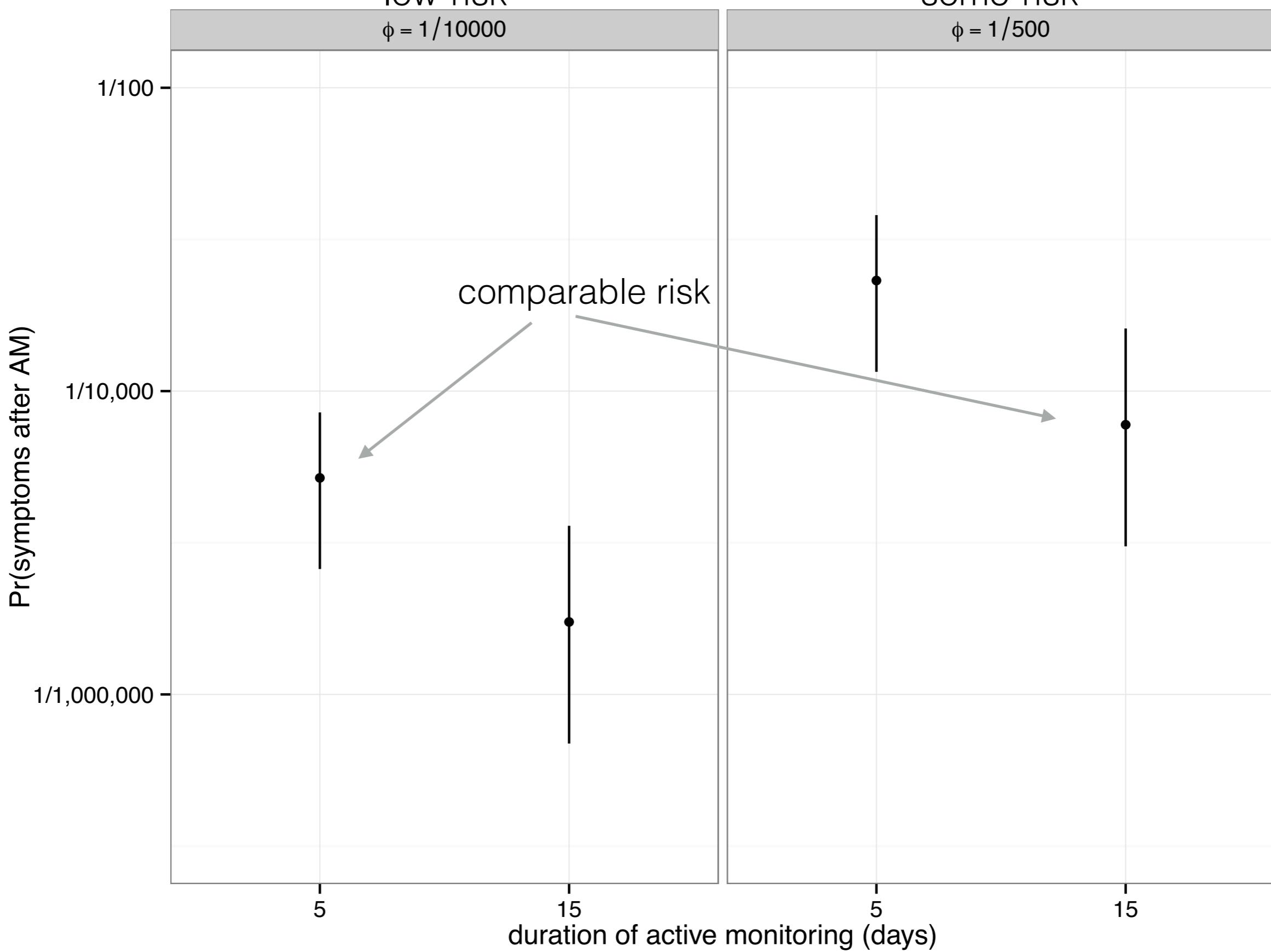
Estimated probability of symptoms during active monitoring with parameter uncertainty, fixed $u=7$ days



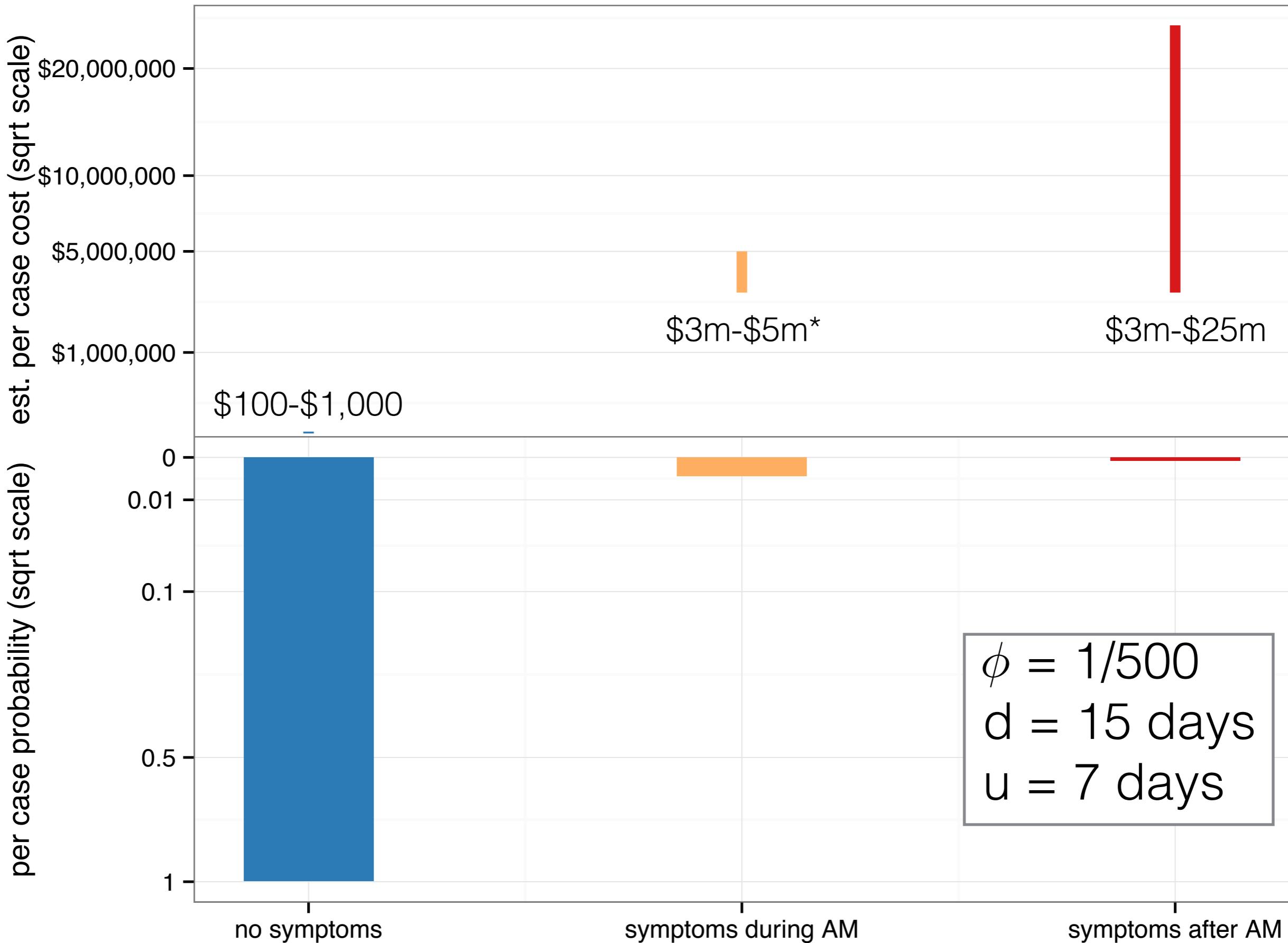
Estimated probability of symptoms during active monitoring
with time-of-exposure uncertainty, i.e. $u \sim \text{Unif}(1\text{d}, 14\text{d})$



Estimated probability of symptoms during active monitoring with both uncertainties



Cost and event probabilities, per case



Conclusions

- Based on Ebola data from Guinea, about 5 in 100 cases will have incubation periods of over 20.3 days (95% CI 18.1 - 23.0).
- More data is needed to characterize the full incubation period distribution and to reduce sensitivity to outlying observations. (WHO recommends at least 200 observations.)
- Public health decision-making in the context of low-probability, high-risk events is challenging.
- Decreasing the duration or frequency of active monitoring for low-risk individuals could create more balanced risk between “low-“ and “some-“risk individuals, while maintaining very low overall probabilities of a case developing symptoms after active monitoring ends.

Thanks!