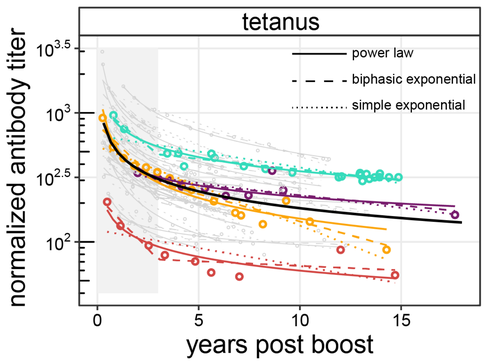
Quantifying the waning of humoral immunity

Ananya Saha[1], Hasan Ahmed[1], Cora Hirst[1], Katia Koelle[1], Andreas Handel[2], Peter Teunis[3,4], and Rustom Antia[1]

[1]Department of Biology, Emory University, Atlanta, GA 30322, USA; [2]Department of Epidemiology and Biostatistics, University of Georgia, GA 30602, USA; [3]Centre for Infectious Disease Control, National Institute of Public Health, RIVM, Netherlands; [4]Hubert Department of Global Health, Emory University, Atlanta, GA 30322, USA.

- Estimating how long protective immune memory lasts is crucial for vaccination schedule design
- No consensus on how antibody titer decay over time following immunization – simple or multiphasic exponential or power law?
- We analyzed data collected by Amanna et al., 2007, NEJM for multiple vaccine and virus antigens

1 Waning is better described by a power law like behavior rather than (bi-)exponential

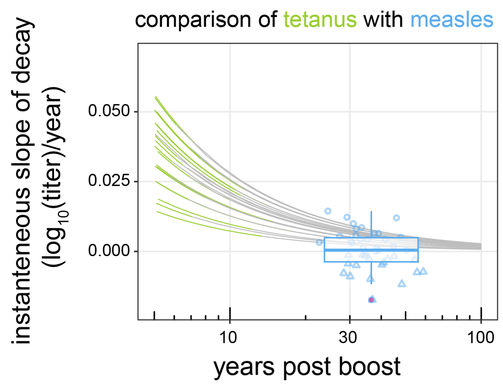


2 Similar results for other vaccines/infections

AIC values for the different models

Antigen	Model		
	simple exp	bi-phasic	power-law
Tetanus	-369.5	-515.8	-579.9 (64.1)
Diphtheria	-181.7	-243.2	-281.8 (38.6)
Vaccinia	25.2	NA	-89.1 (114.1)
VZV	-80.6	-133.2 (1.2)	-132
Measles	-16	-24.9	-27.3 (2.4)
Overall	-335.1	-854.5	-1008.5 (154)

3 Time since immunization is a major factor to estimate rate of waning



Rate of waning of humoral immunity slows over time since immunization, leading to immunological memory lasting longer than previous estimates

Conclusions

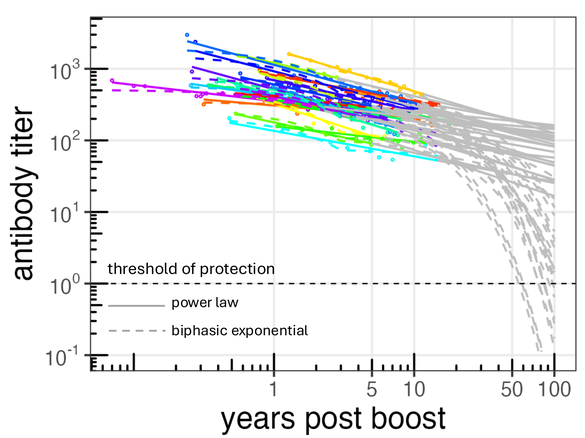
Factors to consider when measuring waning of immunity:

1. Type of immunization - infection/vaccine (type of vaccine)
2. Time post immunization
3. Primary vs secondary and subsequent immune response

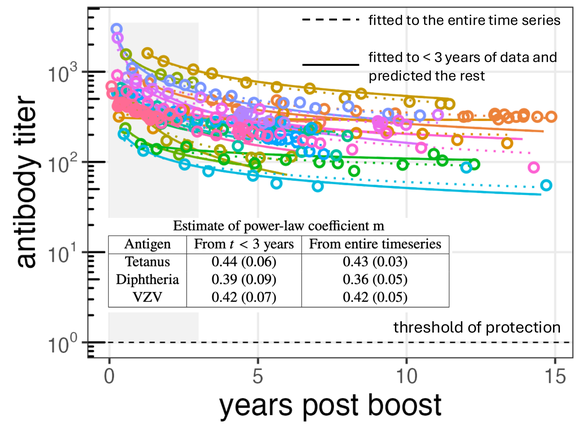
Further considerations:

- Biological mechanisms underlying power law like decay
- Decay after primary vs secondary immunization
- Age dependent changes in protection

4 Immunological memory may last longer than currently estimated



5 Long-term waning can be estimated from short-term data, allowing for rapid vaccine evaluation



Estimate of power-law coefficient m

Antigen	From t < 3 years	From entire timeseries
Tetanus	0.44 (0.06)	0.43 (0.03)
Diphtheria	0.39 (0.09)	0.36 (0.05)
VZV	0.42 (0.07)	0.42 (0.05)

I. J. Amanna, N. E. Carlson, and M. K. Slifka. Duration of humoral immunity to common viral and vaccine antigens. N Engl J Med, 357(19):1903–1915, 2007.

I. Simons, B. D. & Karin, O. Tuning of plasma cell lifespan by competition explains the longevity and heterogeneity of antibody persistence. Immunity 57, 600–611.e6403 (2024).

ananya.saha@emory.edu