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Title: Modeling the impact of spatial heterogeneity, behavior change, and mitigations on the current Ebola epidemic

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Modeling the the impact of spatial heterogeneity, behavior change, and mitigations on the current Ebola epidemic

Update to MIDAS group, 7 October, 2014

Ben McMahon, Paul Fenimore, Nick Hengartner, Sara del Valle, Ruy Ribeiro (LANL)

Mac Hyman

(Tulane)

Multi-Scale Epidemiology (MuSE)
to capture evolving spatial heterogeneity

Combines the advantages of network patch SEIR-like models:

- exponential epidemic rise, saturation, and fall in well-mixed compartments
- rapid to compute
- easy to match to empirical data

with the advantages of agent-based models at larger scales:

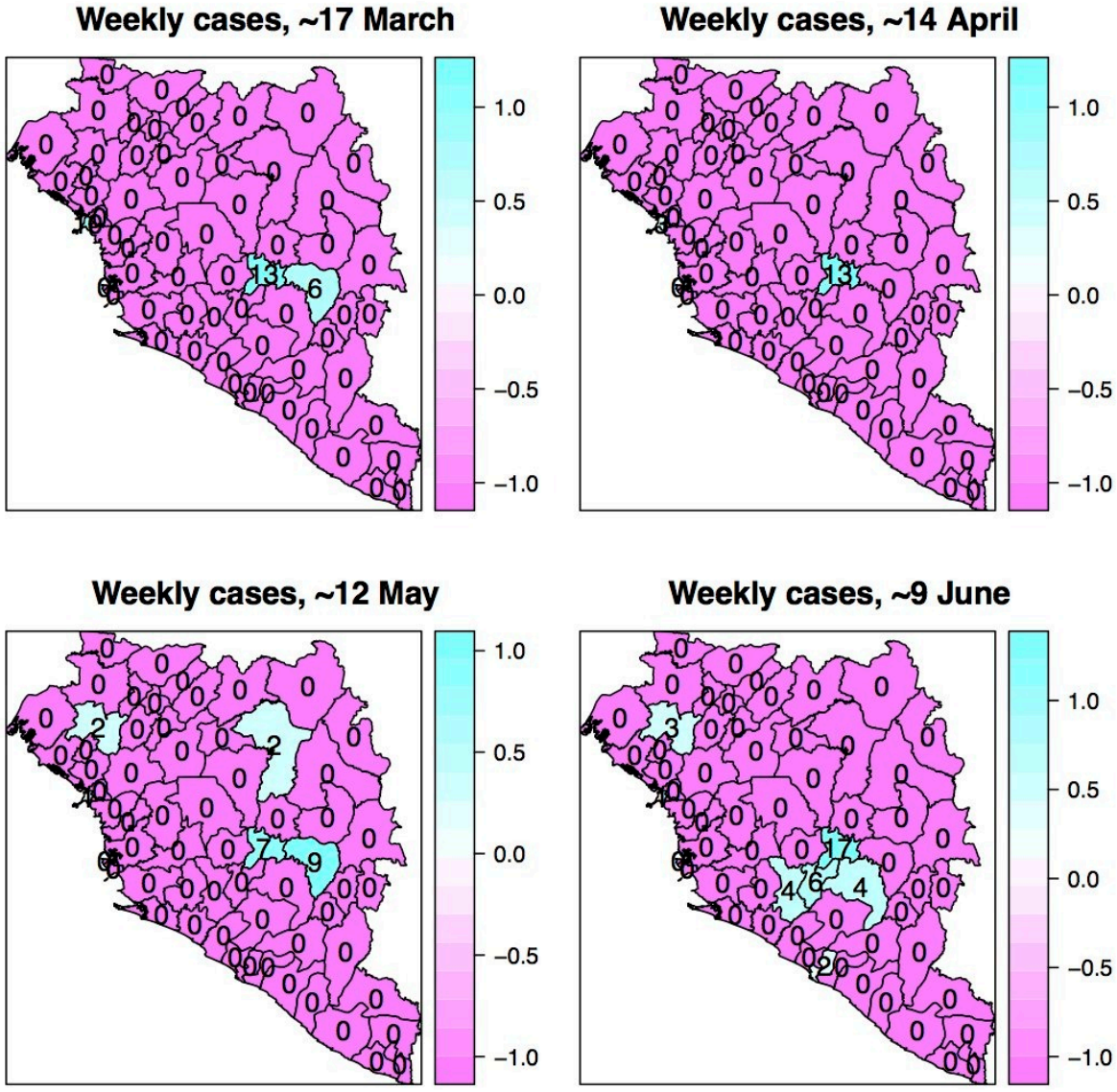
- flexible and explicit rule-based mitigations
- realism (transferability)
- multi-pathogens and age cohorts, with arbitrary transmissibility and susceptibility matrices between hosts
- **Like a risk-map, but with dynamics**

MuSE references:

- Manore, et al. Rinderpest, BMC Res. Rep, 2011
- McMahon, et al. RVF, Math. Mod. Nat. Phen. 2014
- Labute, et al., FMD, HPAI in USA, ISPRS J., 2014
- Jeanne Fair lead much of this development → CBEP

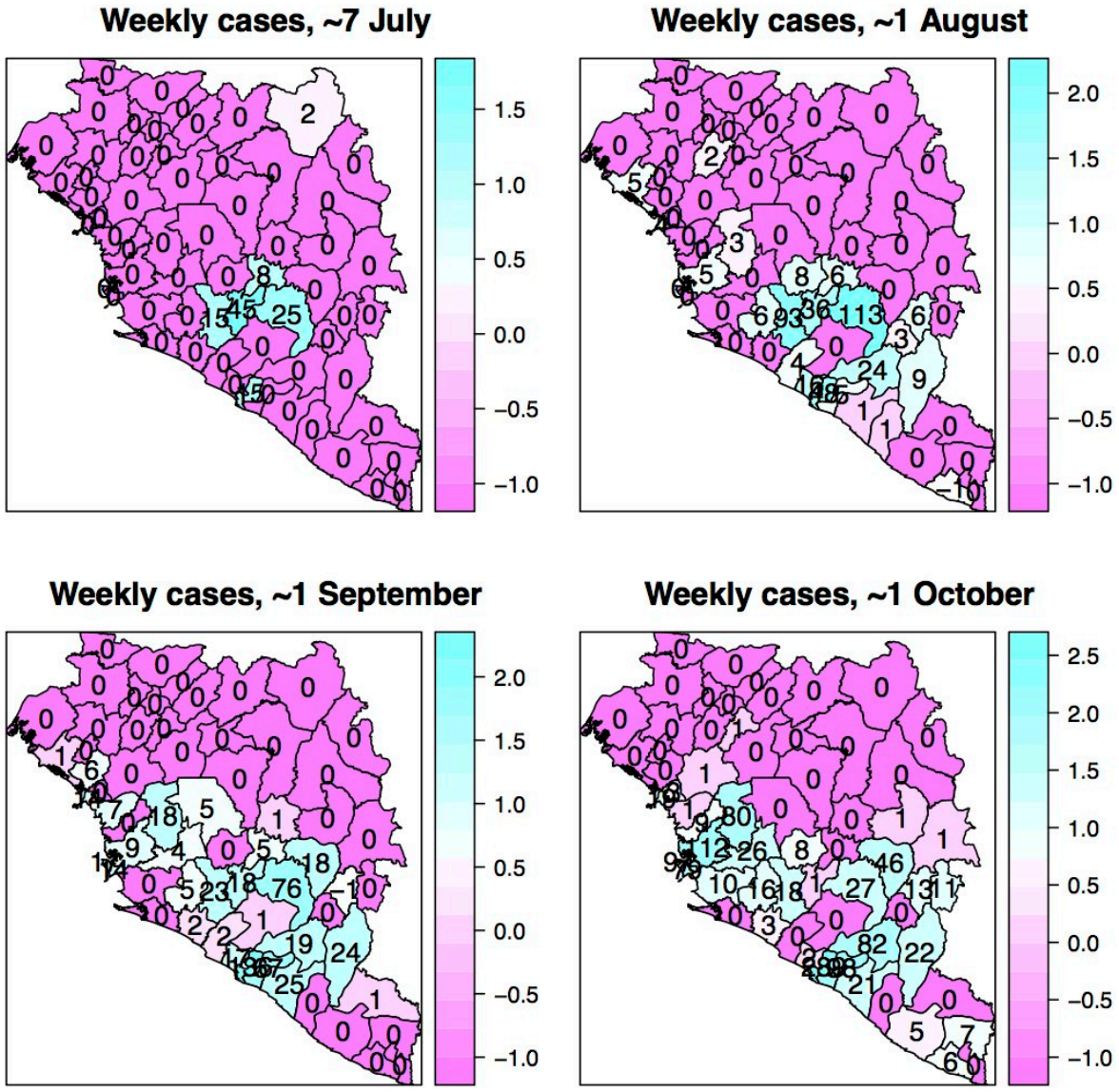
Need for spatial-temporal epidemic models

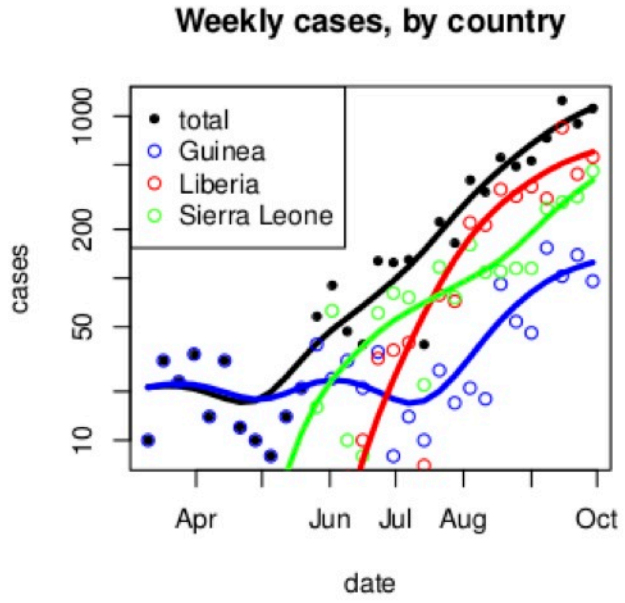
Early weekly cases stayed confined to a few small regions

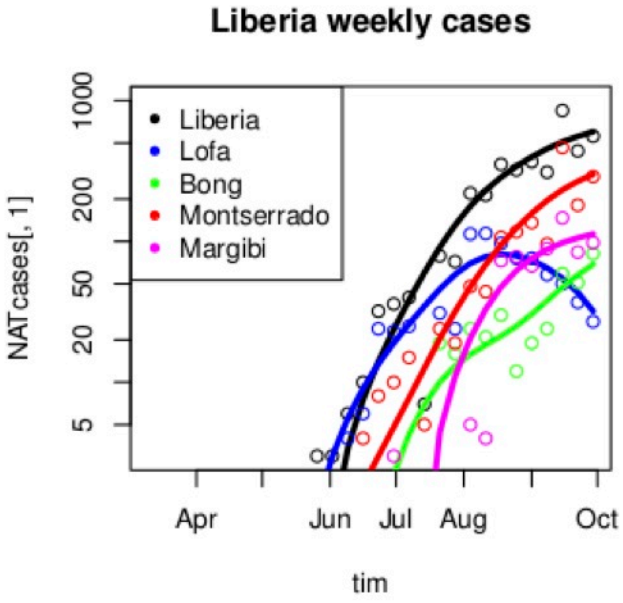


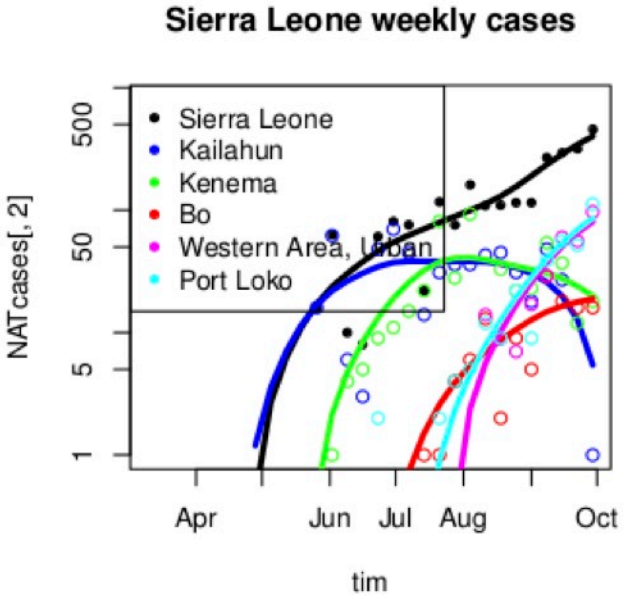
Need for spatial-temporal epidemic model

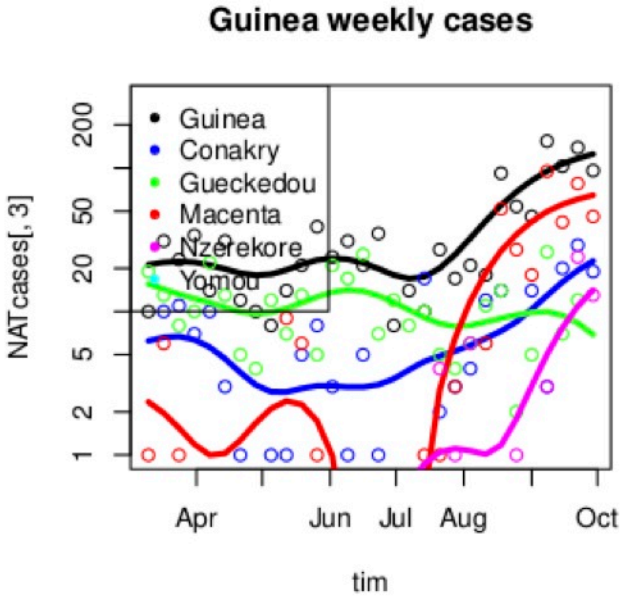
Weekly cases spread slowly to nearby counties











Time-courses confirm significant geographic heterogeneity under 'relentless exponential growth' in aggregate data.

Gueckedou, Lofa, and Kailahun, improving & the cities getting worse.

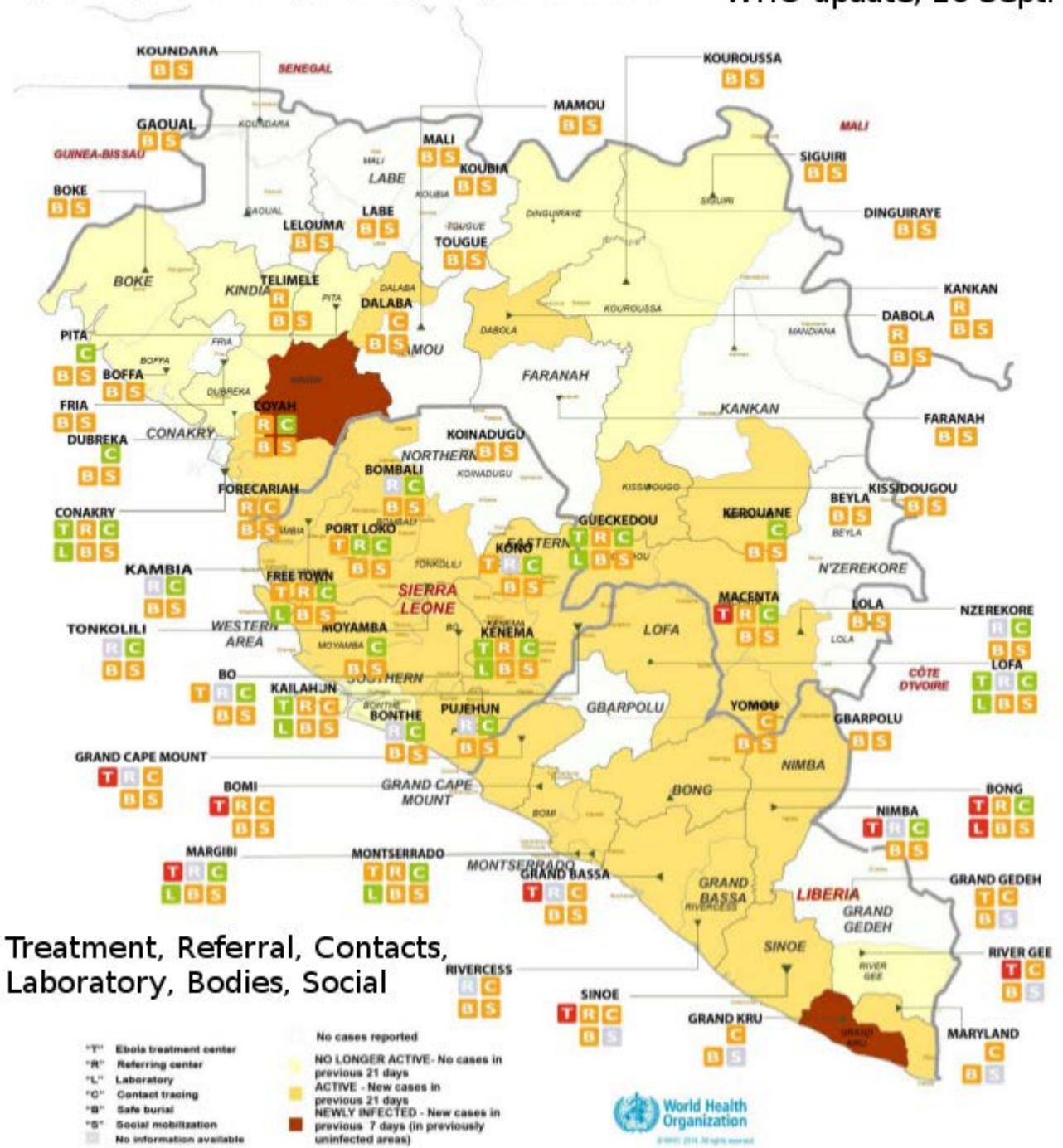
Three drivers are behind this heterogeneity:

- Re-introductions
- Learning curves
- Resource limitation

Symbols: Weekly counts taken from publically available Ministry of Health data.
Lines: Smoothing splines to guide the eye.

Figure 2: Response monitoring for Guinea, Liberia, and Sierra Leone

WHO update, 26 Sept.



The 'learning curve' from WHO

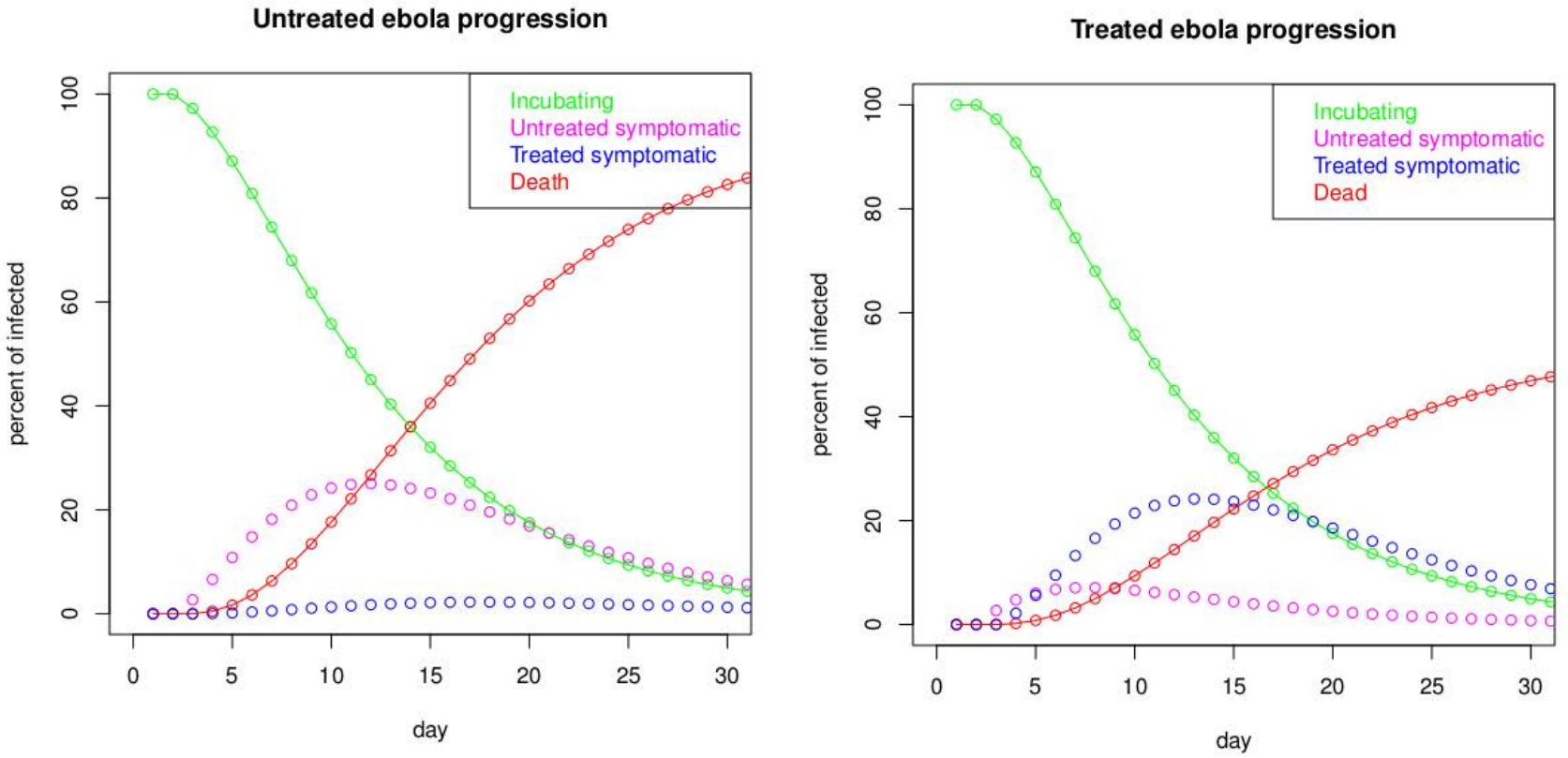
<u>Defined in six areas:</u>

Treatment
Referral
Contact tracing
Laboratory capacity
Safe body recovery
Social mobilization

<u>In terms of:</u>

Not needed
Functional
Plan in place
Non-functional

Disease progression strongly couples treatment to transmission control



Adapted from Chowell, Hengartner, Castillo-Chavez, Fenimore, Hyman, "The basic reproductive number of Ebola and the effects of public health measures: the cases of Congo and Uganda" J. Theor. Biol. 7:119-126 (2004).

We are working back and forth between fits to data in slide 3 and ways of representing mitigations vs. time and county