Design and analysis of prevalence surveys for NTDs: how to increase model uptake?

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Neglected tropical diseases

"A diverse group of communicable diseases that prevail in tropical and subtropical conditions in 149 countries – affect more than one billion people and cost developing economies billions of dollars every year."

Major attributes of the NTDS

- most prevalent among poor people
- associated with high disease burden but low mortality
- endemic in rural areas of low-income countries
- chronic
- disabling (growth delays, blindness, or disfigurement)
- stigmatizing

Burden of NTDs in the world

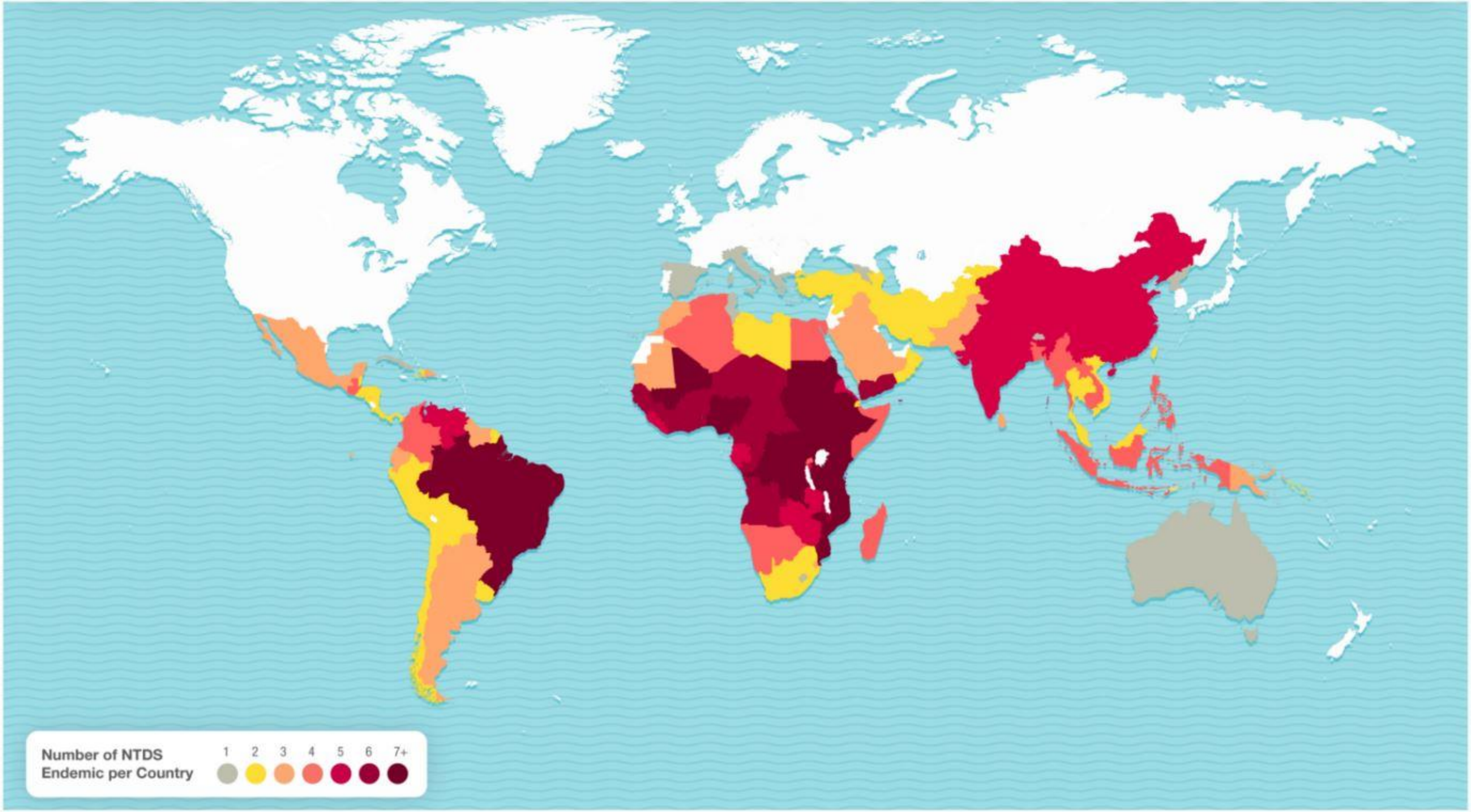
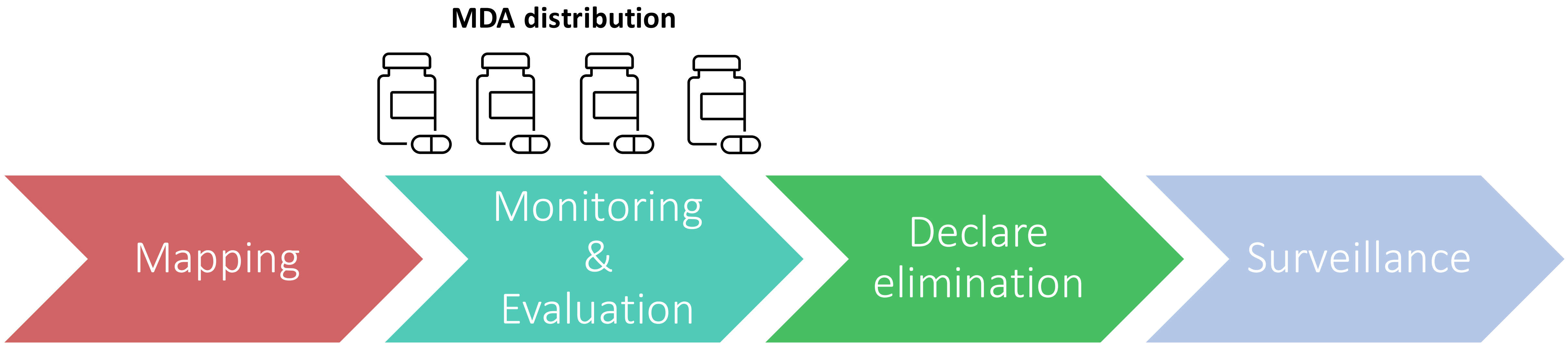


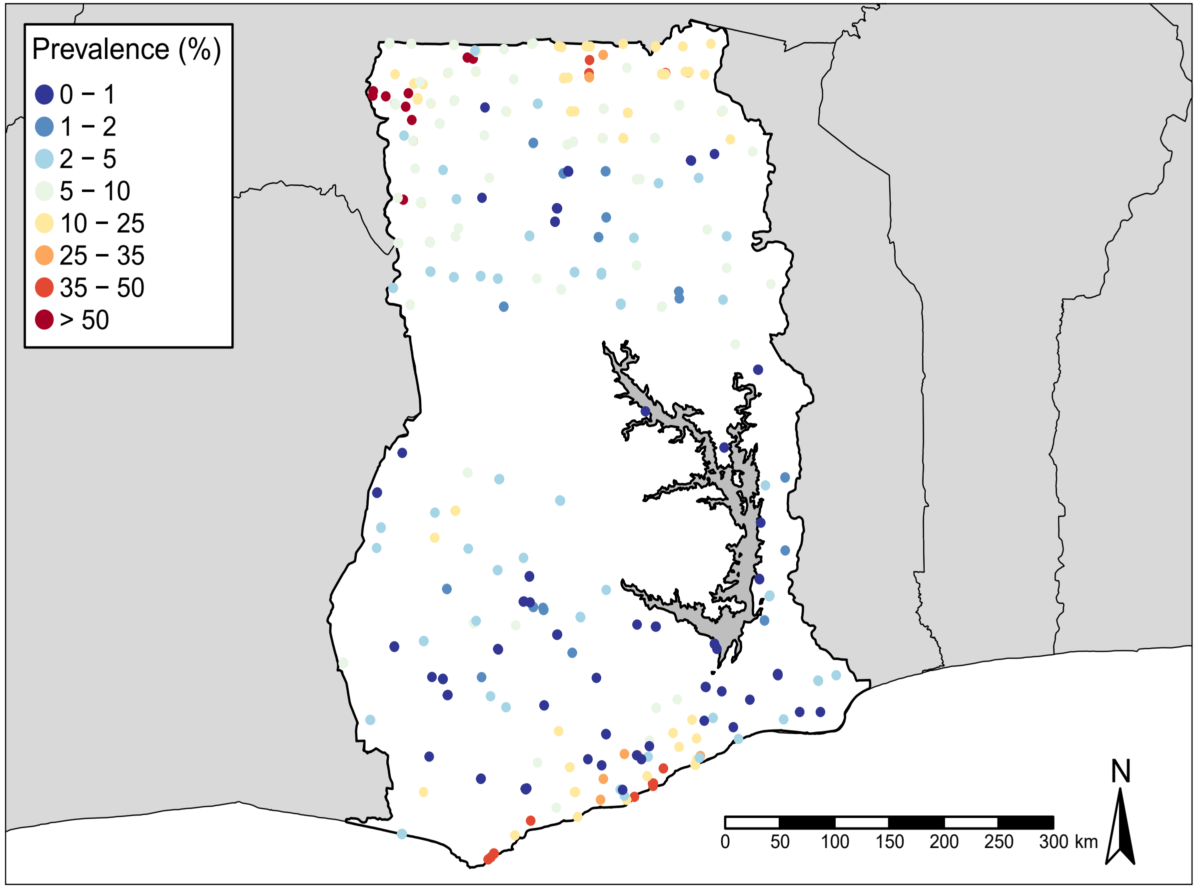
Fig. 1: NTDs endimicity based on 2009-2010 data. Source: https://unitingtocombatntds.org/.

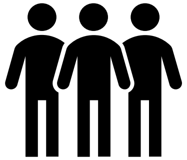
NTD control programme stages



Prevalence surveys

Lymphatic filariaris (LF) mapping surveys in Ghana





Limited resources allow to samples only a small portion of the population.

Imperfect diagnostic tests.

Mapping surveys

Collect prevalence data: (x_i, m_i, Y_i) $i=1,\ldots,n$

- asses the endemicity status
- decide the appropriate treatment

Understanding the **spatial** distribution and burden of the disease is essential to inform disease control policies.

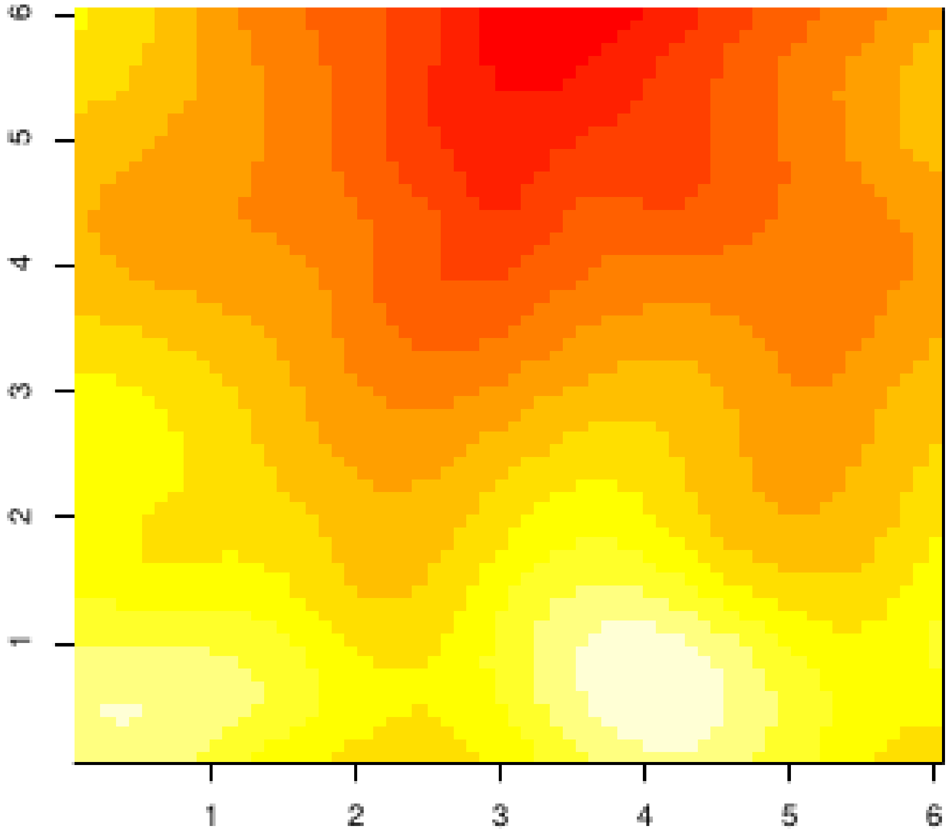
The role of model-based approaches

Provide a set of tools that can:

- improve the **design** and **analysis** of prevalence surveys
- support decision making under **uncertainty**.

Why use model-based geostatistics?

Area-wide prevalence = 41.7%



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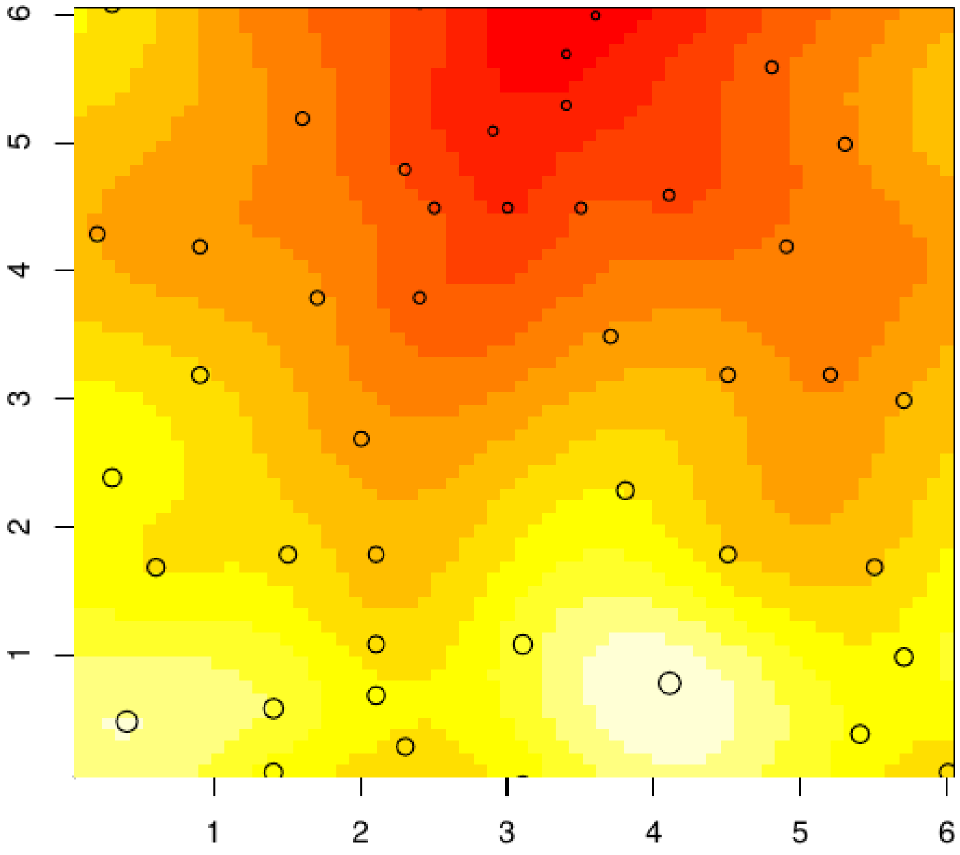

Measure prevalence at sampling locations

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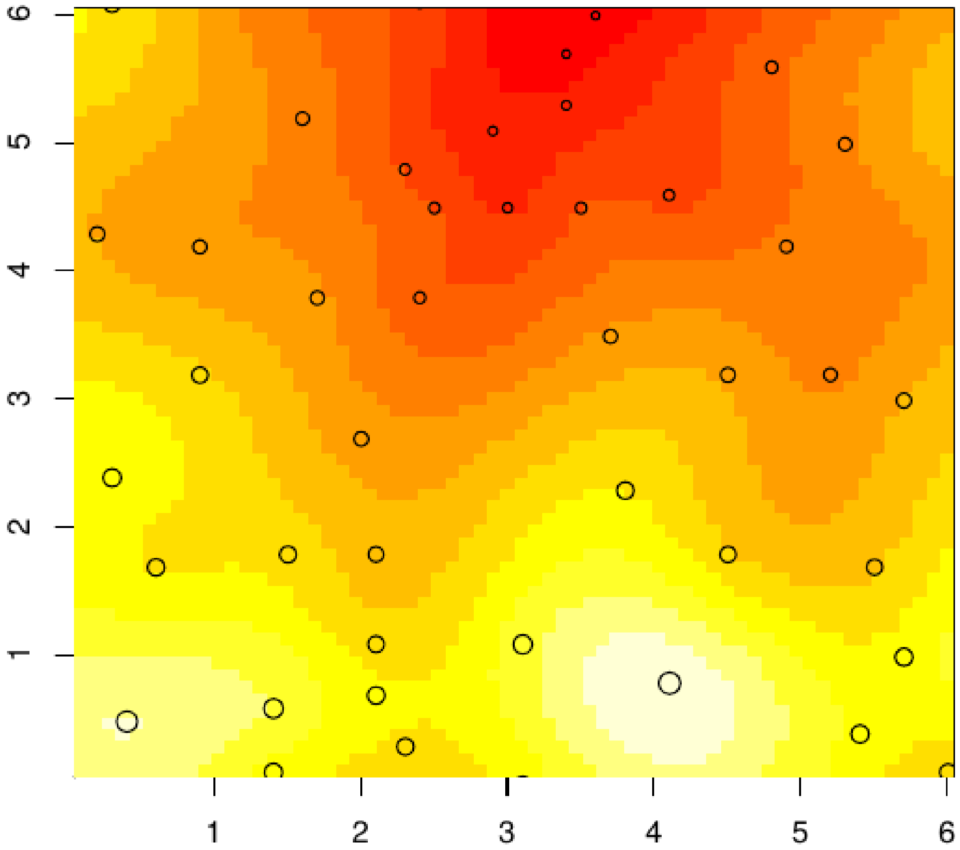

Measure prevalence at sampling locations

Survey sampling analysis

41.3 ± 8.6

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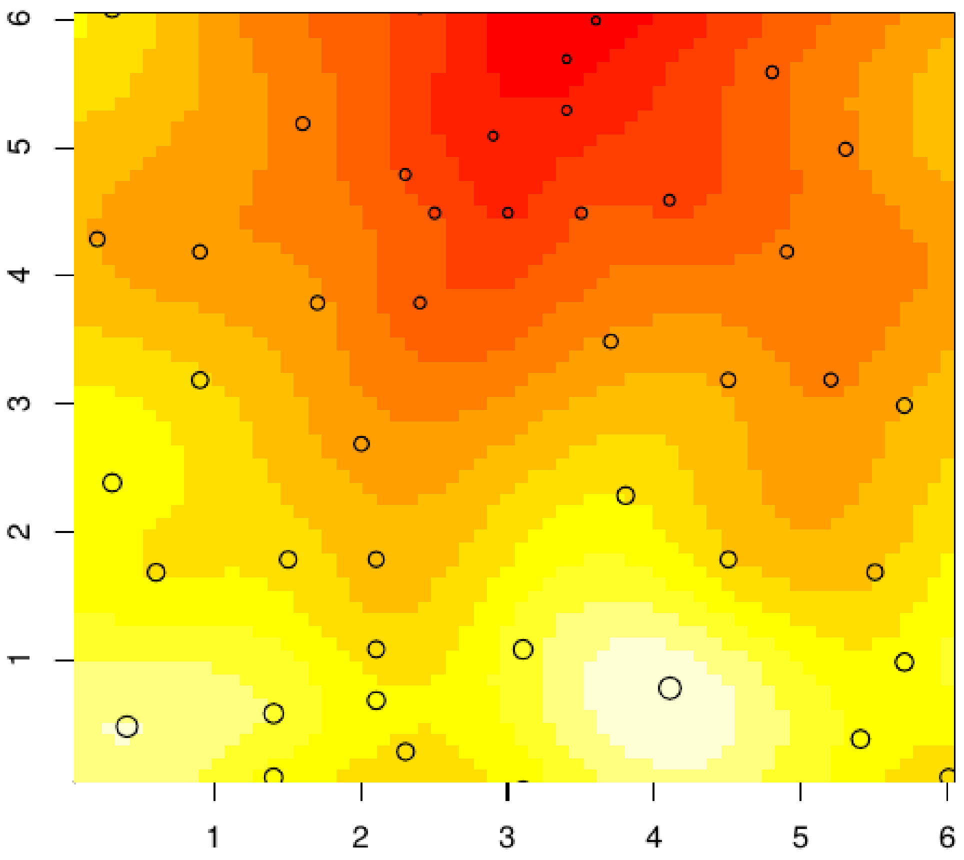


Measure prevalence at sampling locations

Survey sampling analysis

41.3 ± 8.6

Geostatistical analysis

41.6 ± 1.4

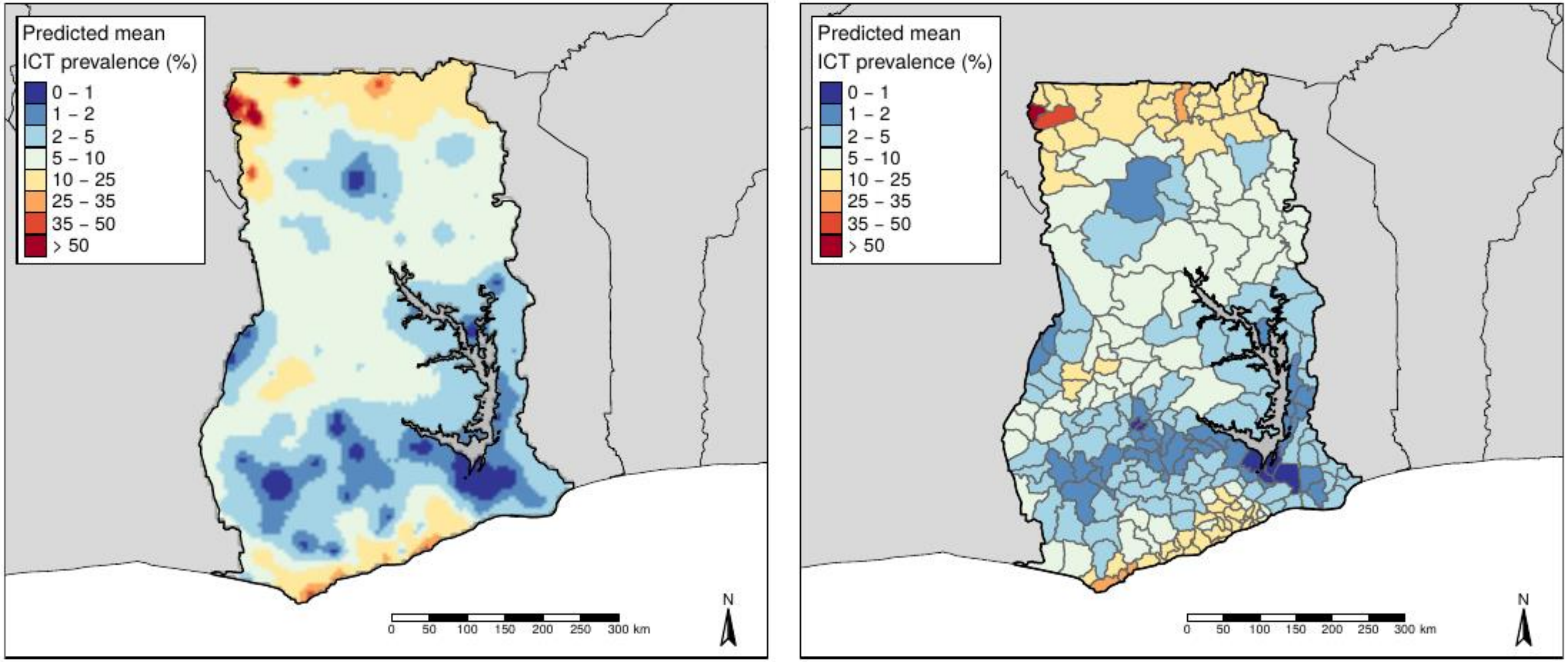
Where does the extra efficiency come from?

Exploiting spatial correlation

- Data at location x are informative of prevalence at “neighbouring” locations x'
- Model-fitting process allows data to choose optimal definition of “neighbouring”

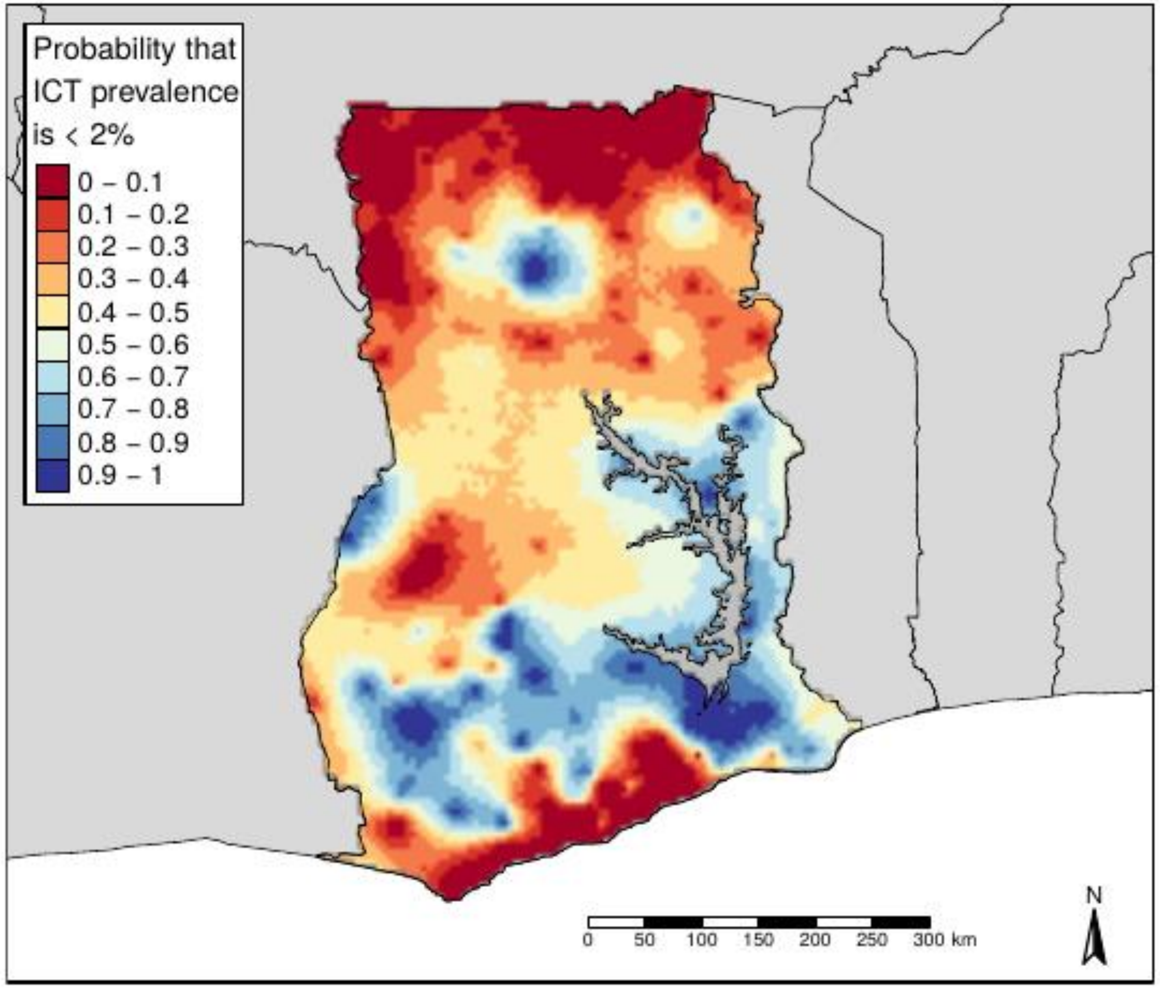
Model-based geostatistics

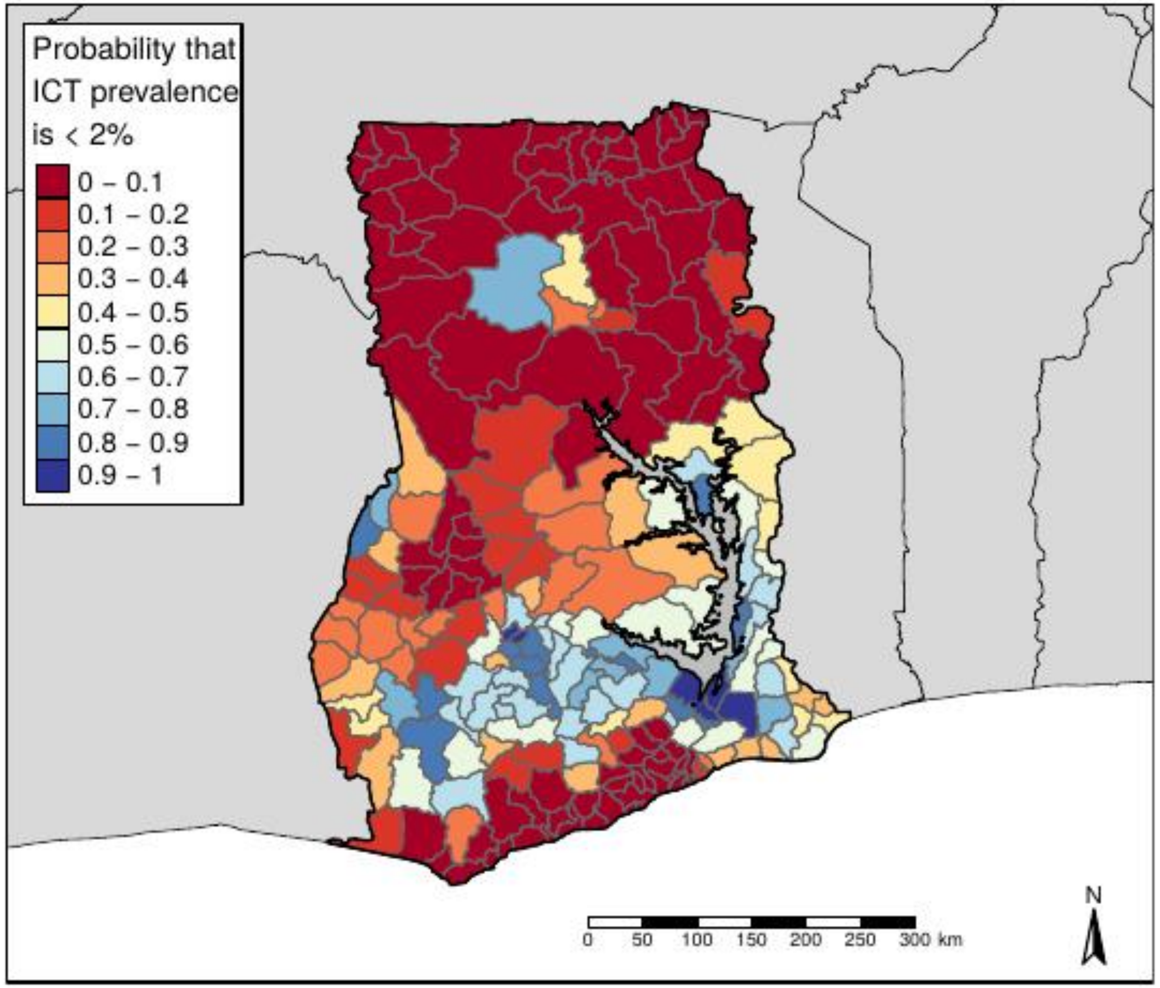
Exploits **spatial correlation** present in the data to predict the summary of interest at any **unsampled location** and any **desired spatial scale**.



Model-based geostatistics

Honest reporting of the **uncertainty** around the prediction target of interest.



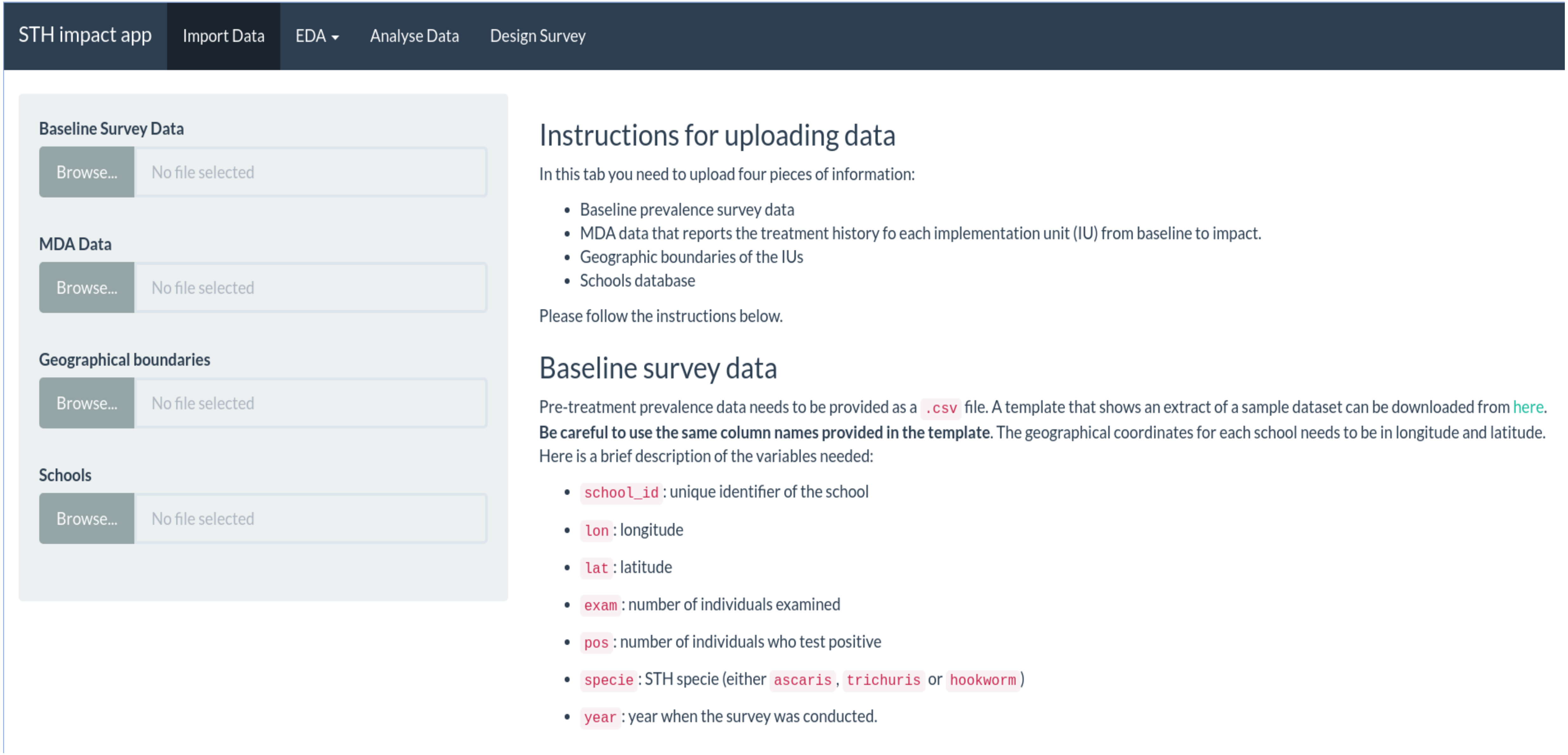


How about model-uptake?

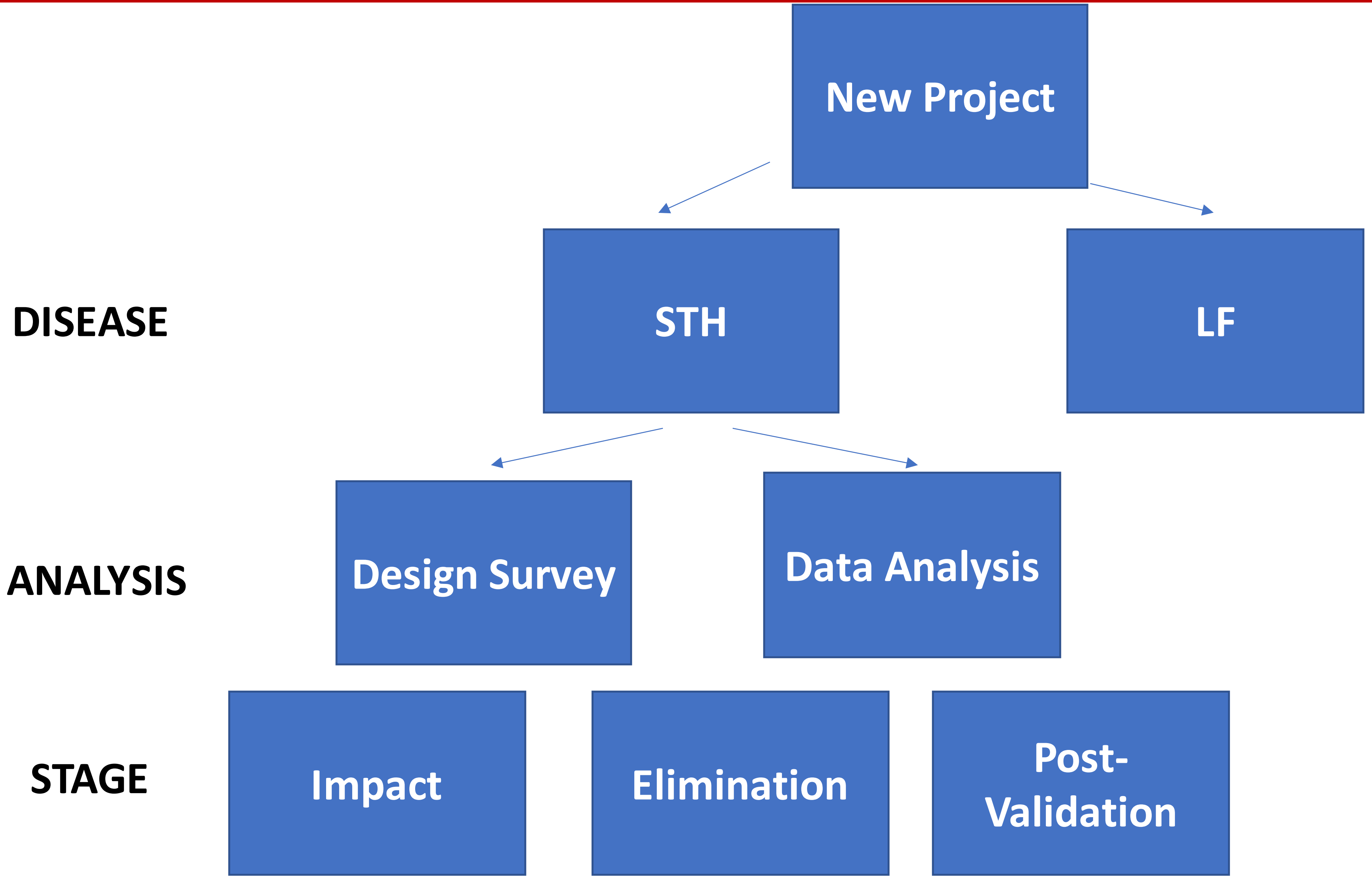
Statistical and technical skills required to implement these approaches.

```r
# MODEL-BASED DECISION WITH GEOSTATISTICS ------------------------------
for (i in 1:nrow(scenarios)) {

  message("Doing scenario ", scenarios$ID[i])

  # Assign number of children to test according to scenario
  schools$examined <- scenarios$children[i]

  # Simulate number of children tested positive according to
  # underlying true prevalence
  schools$positive <- rbinom(n = nrow(schools),
                             size = schools$examined,
                             prob = schools$true_prev)
  schools <- as.data.frame(schools)

  # Sample schools accordying to the sampling strategy
  # (either random or regular)
  if(scenarios$sampling[i] == "random") {
    sample_id <- sample(nrow(schools), scenarios$nschools[i], size = )
    schools_sampled <- schools[sample_id, ]
  } else {
    delta <- 10 # minumun distance allowed between pairs (in km)
    sample_id <- geo_sample(xy.all = schools[c("utm_x", "utm_y")],
                            n = scenarios$nschools[i],
                            delta = delta, k = 0)
    schools_sampled <- schools[sample_id, ]
  }

  # Fit geostatistical model to simulated data
  schools_sampled$logitp <- with(schools_sampled, elogit(positive, examined))
  schools_sampled$prev <- schools_sampled$positive / schools_sampled$examined
```

User-friendly web applications



Geostat NTD Hub



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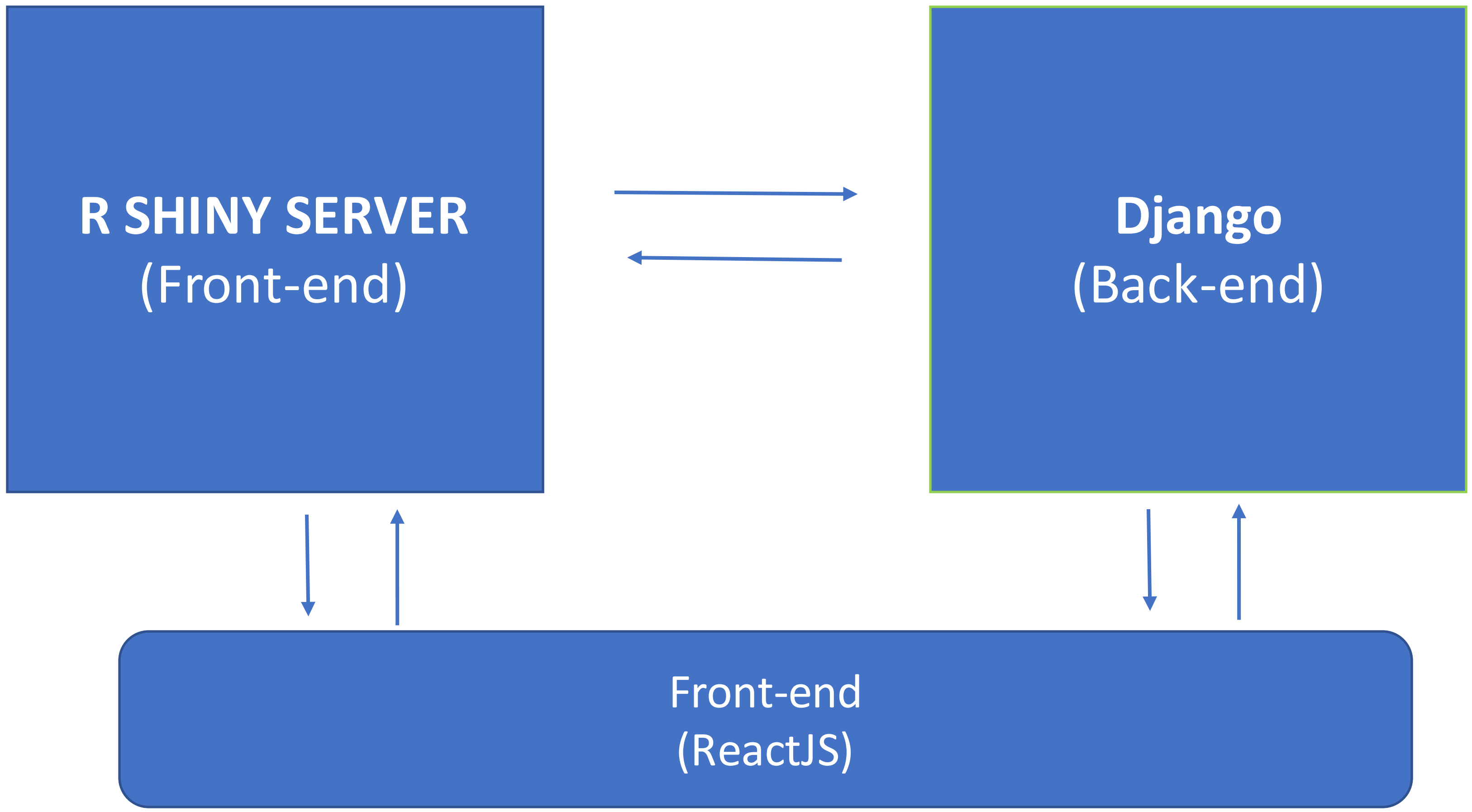

References

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Thank you!