Universiteit Utrecht

SUMMERFAIR
combining data science and infection models for estimating transmission parameters

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Transmission in small populations

Photo Dr. Anita Dame-Korevaar

Context:
Transmission experiment with ESBL-producing E. coli.
Challenge at 8:00, swaps taken at 16:00 daily
Samples are cloaca swaps put on plate after standard dilution series
- = no growth on selective plate, 1-5 = log concentration ESBL-producing E. coli, <1 is positive but too little to count, >6 positive but too many to count

		Sample_time (days post challenge)							
Host_id	**Challenge**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	Yes	2	5	>6	4	3	4	-	-
2	Yes	1	-	-	-	4	5	6	5
3	Yes	<1	5	4	2	1	-	<1	-
4	No	-	-	4	3	-	4	4	-
5	No	-	<1	2	-	-	3	-	-
6	No	-	-	4	3	-	-	-	<1

Infection status of an animal?

- Biological / epidemiological factors:
  - Passage of inoculum
  - Intermittent shedding
  - Sensitivity and specificity of test

		Sample_time (days post challenge)							
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- = no growth on selective plate, 1-5 = log concentration ESBL-producing E. coli, <1 is positive but too little to count, >6 positive but too many to count

Infection status of an animal?

- Which infection model:
  - Direct or indirect
  - Latency period
  - Recovery

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Infection status of an animal?

- Example:
  - S-I-S model
  - Low concentration after inoculation = passage

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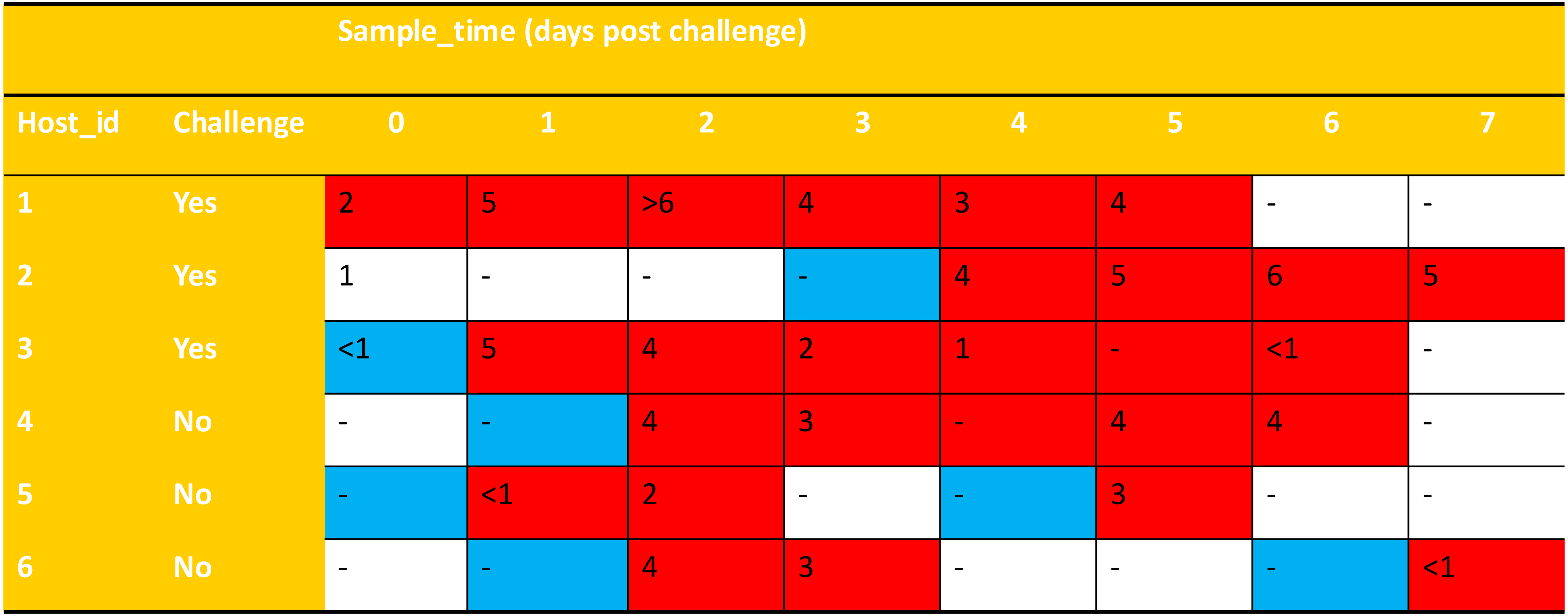
Infection status of an animal?

- Example:
  - S-L-I-S model
  - Assuming possibility of false negative if only once negative
  - Low concentration after inoculation = passage



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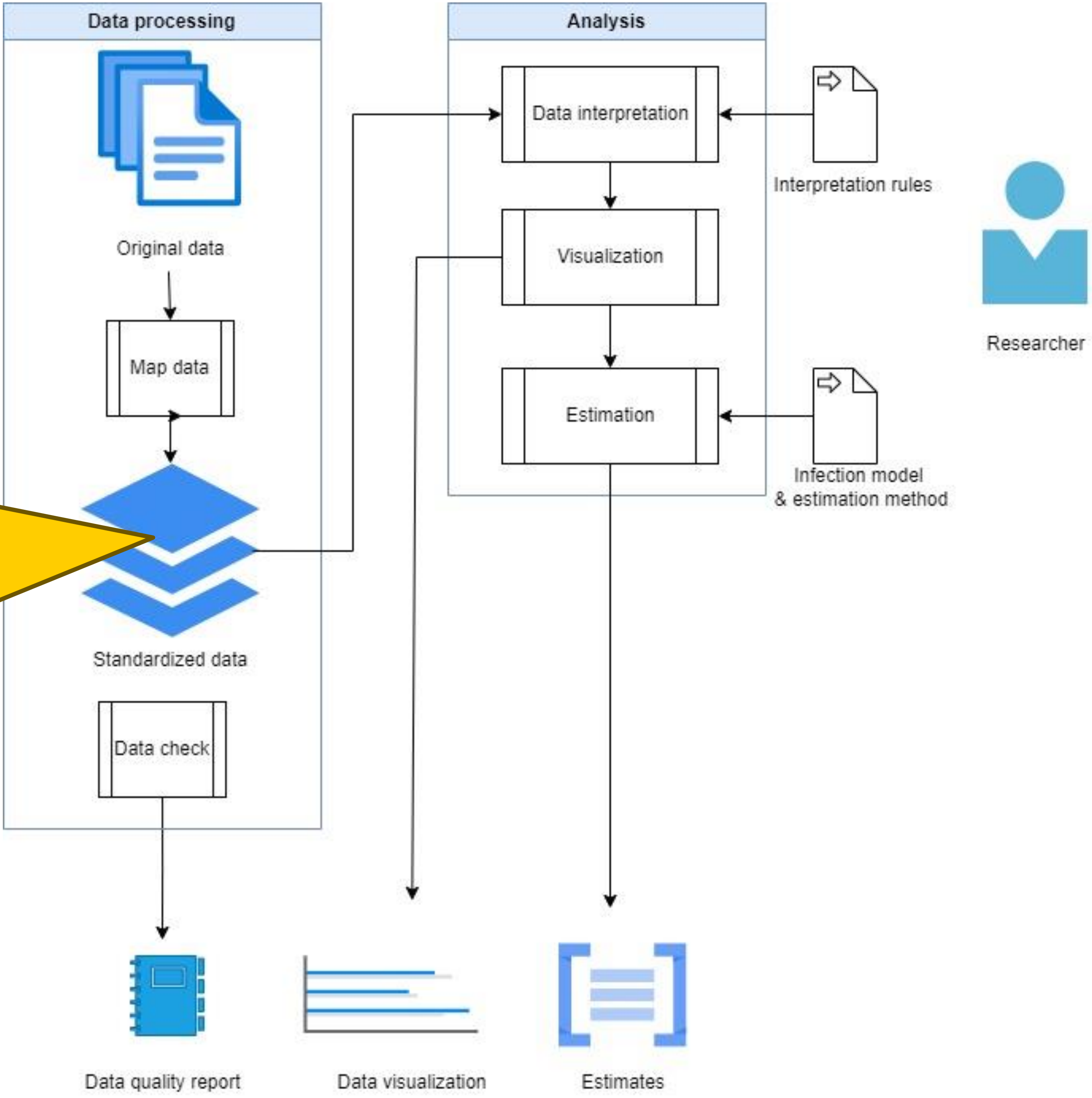
Objective of SUMMERFAIR framework

- Facilitate application of different models and assumptions on transmission data in small populations

This requires **standardization of input data**

It allows for
- **Data quality** reports
- **Visualisation**
- Easy documentation and reproducibility of **data interpretation**



Data processing

Original data

Map data

Standardized data

Data check

Analysis

Data interpretation

Visualization

Estimation

Interpretation rules

Infection model
& estimation method

Researcher

Data quality report

Data visualization

Estimates

Based on
Infection Transmission
Ontology

Slavco et al. 2022
https://doi.org/10.1109/eScience55777.2022.00021

Data Mapping

- hosts.csv

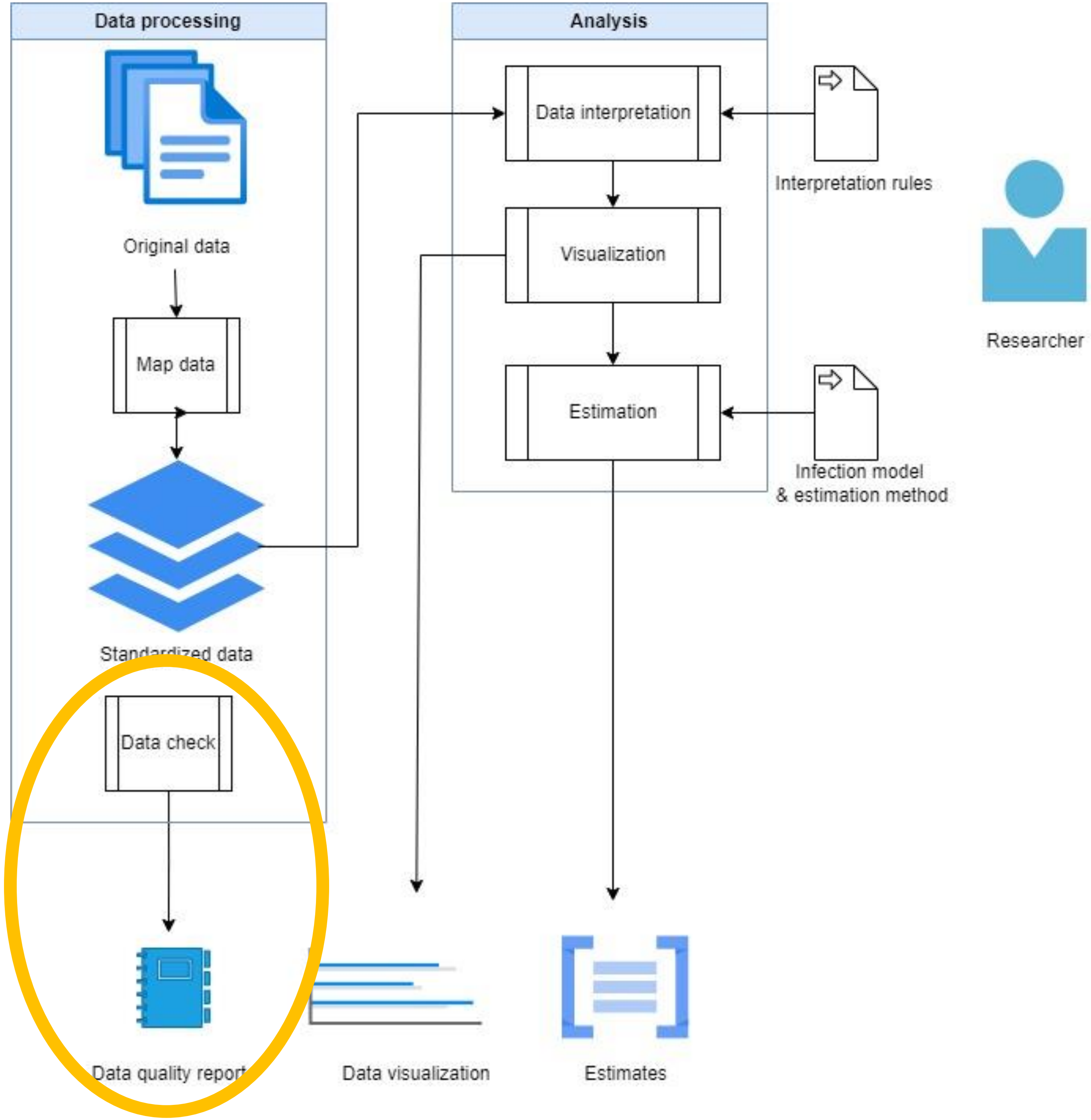
id, sex, group, birth, death

- environments.csv

id, date, time, housing type, housing id, level

- host_events.csv
- environment_events.csv

host id / housing id, date, time, measurement, intervention, treatment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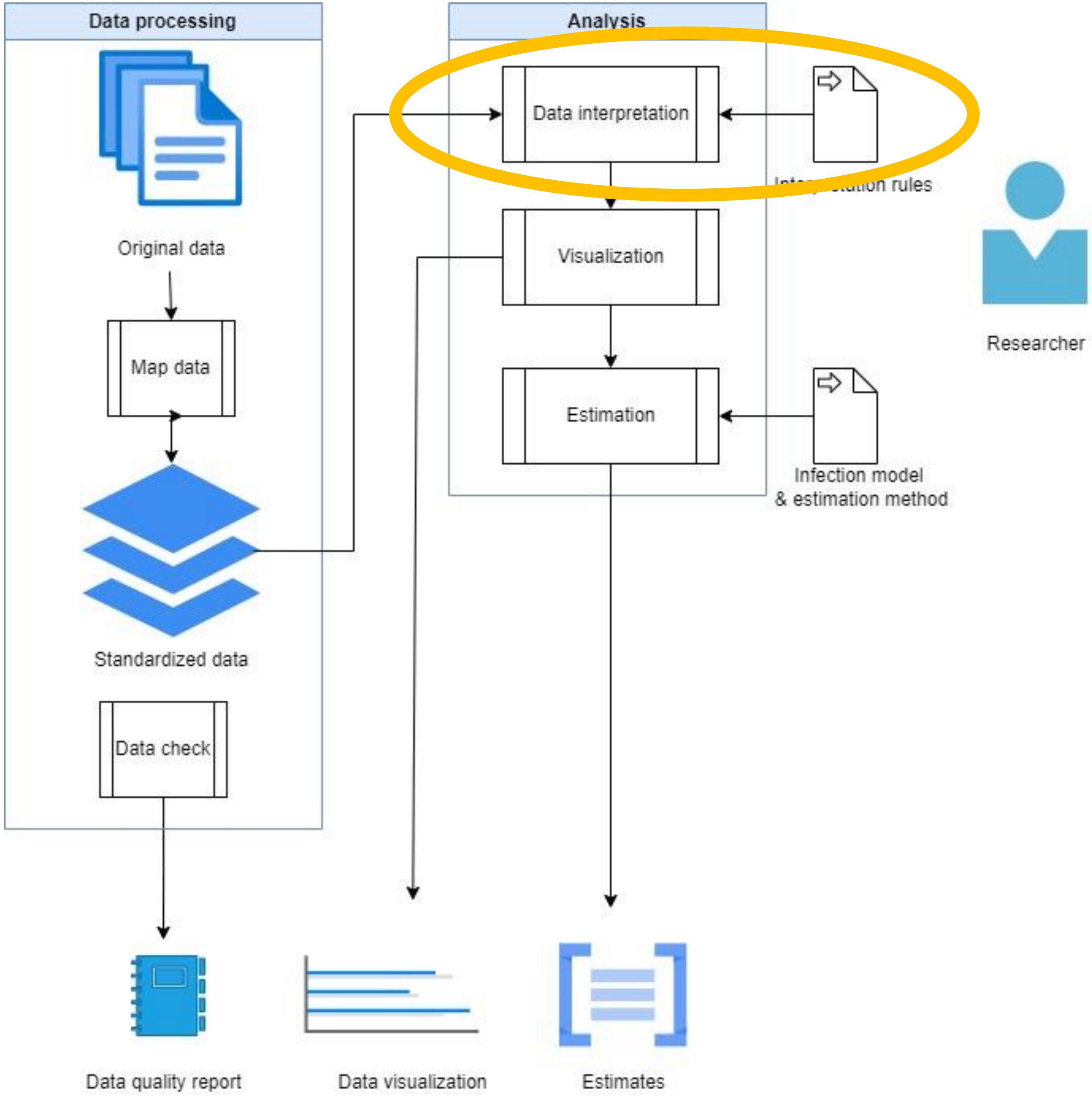

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Data interpretation rules

- Generic structure:

```
##generic of a rule ####
rule.generic <-function(timeseries,var.id,…){…}
```

- Returns a vector with 0,1,2 or 3 which codes for susceptible, latent, infectious and recovered.

- Preprogrammed *rules* are names
  rule.<interpretation>.<additional features>

Data interpretation rules

- Preprogrammed rules with one input vector

- `asis, sincefirst, consecutive`

- Preprogrammed rules with multiple input vectors

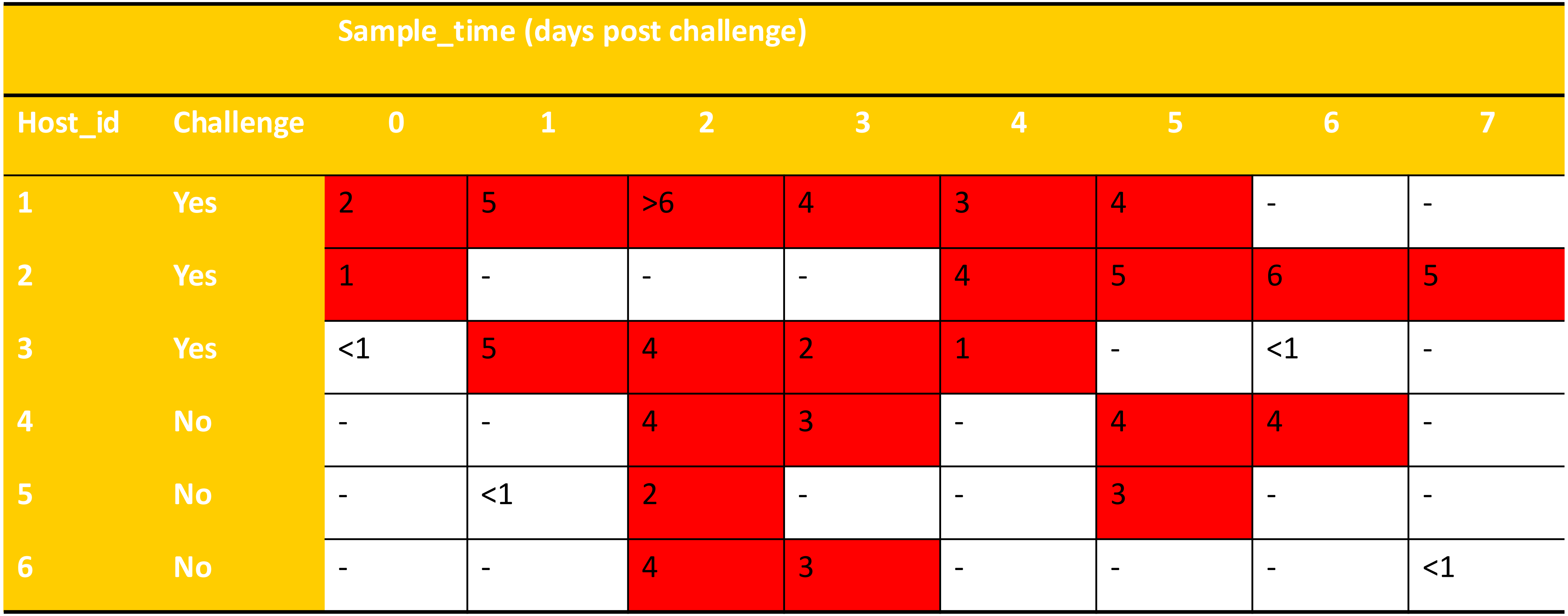
- `any, sinceany, infectiousrecovered`

- Additional features:

- `recode, detectionLimit, cutoff`

Interpretation rule `asis.cutoff`

`cutoff = 1`



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Interpretation rule `consecutive.cutoff`

`cutoff = 1`

`2 consecutive days  = positive / negative`

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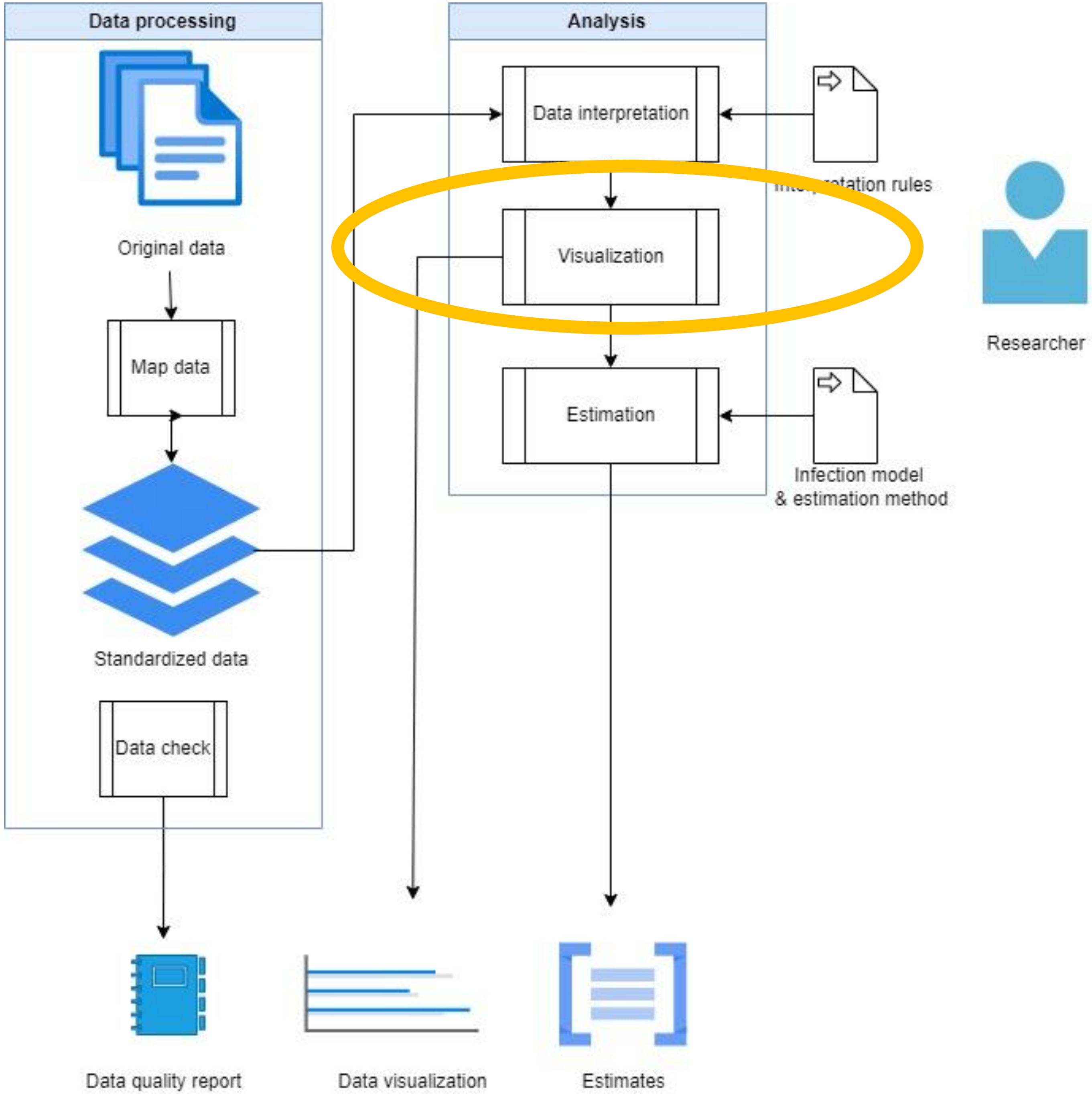

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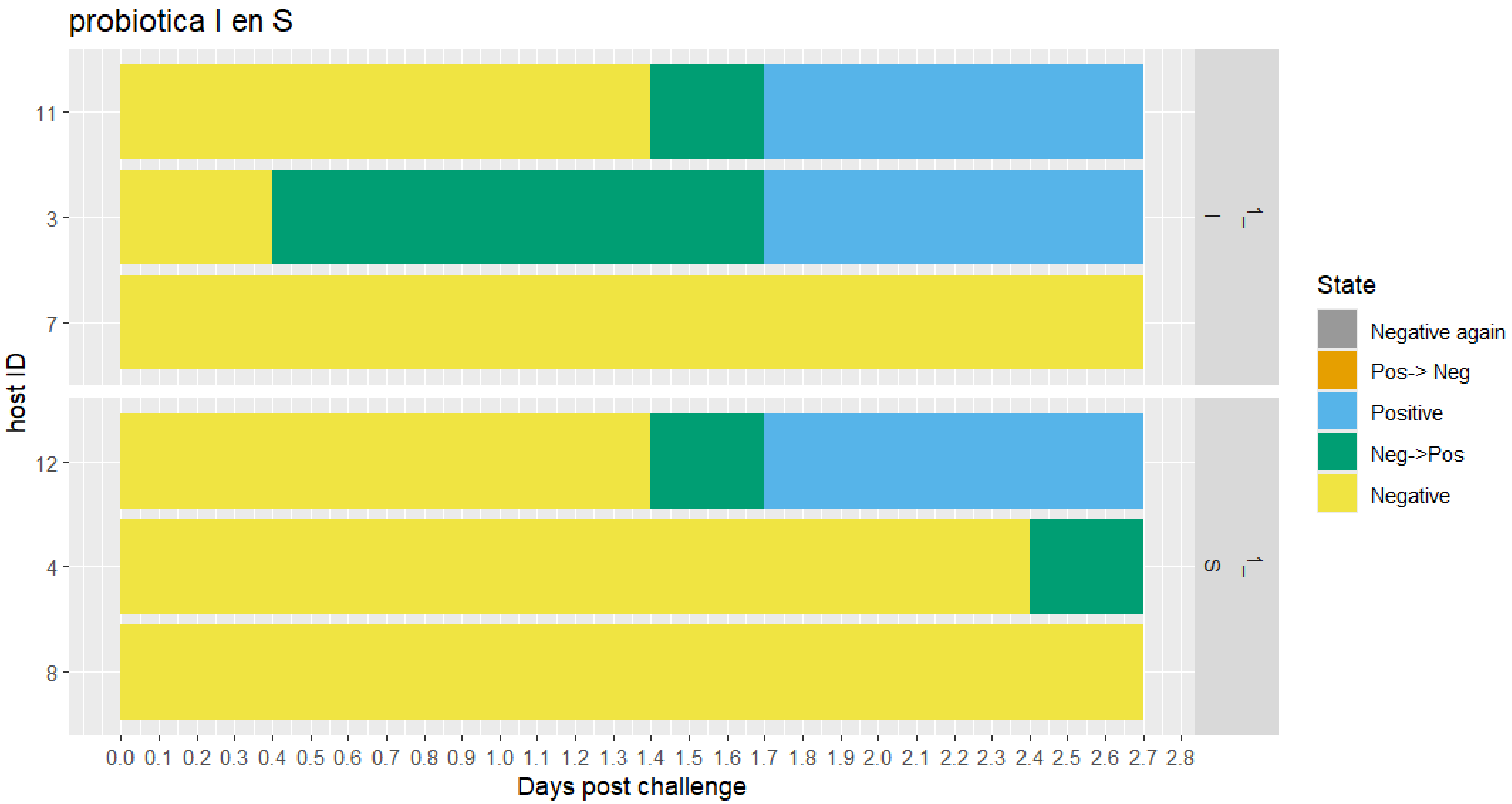
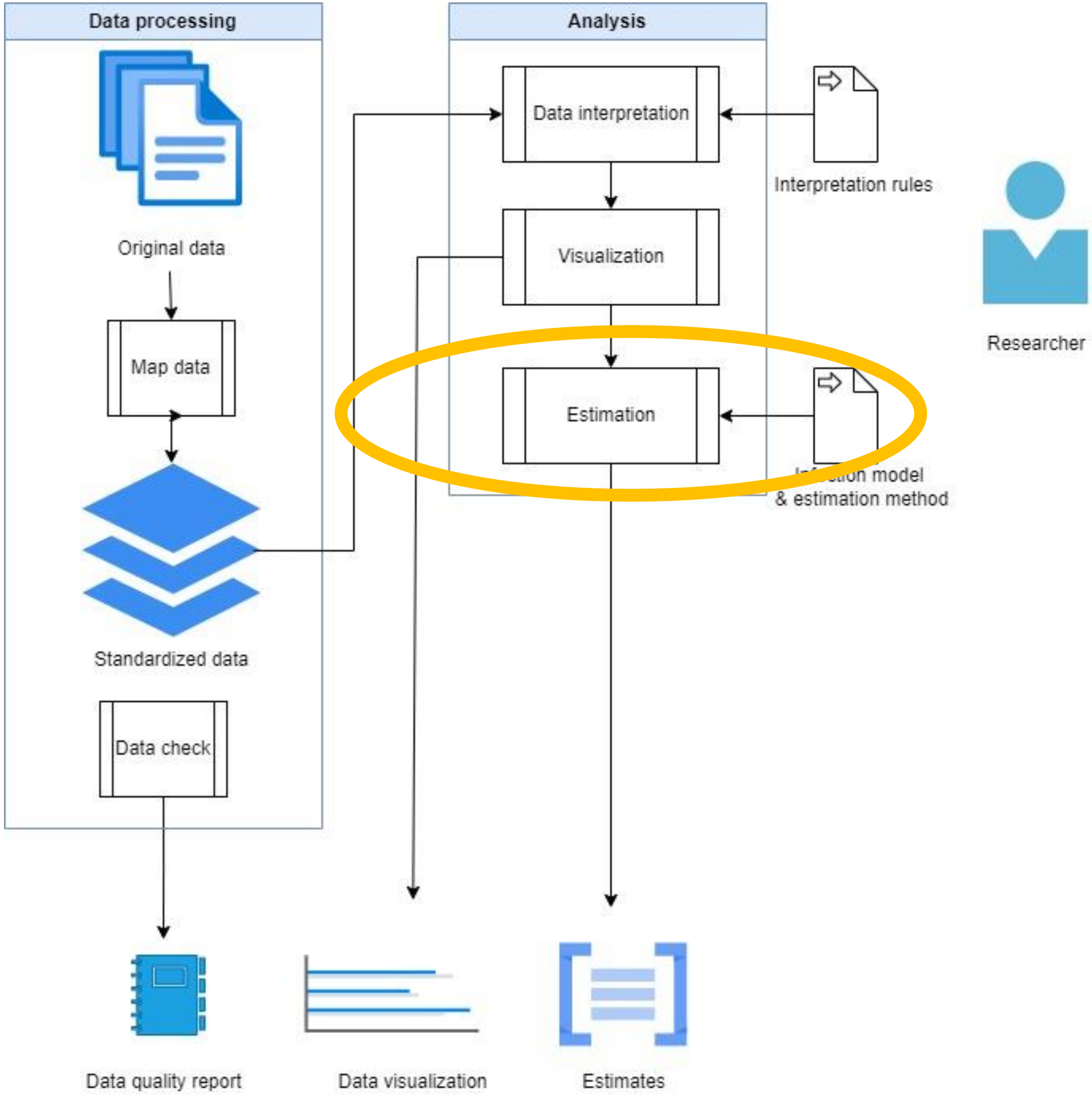
Data visualisation





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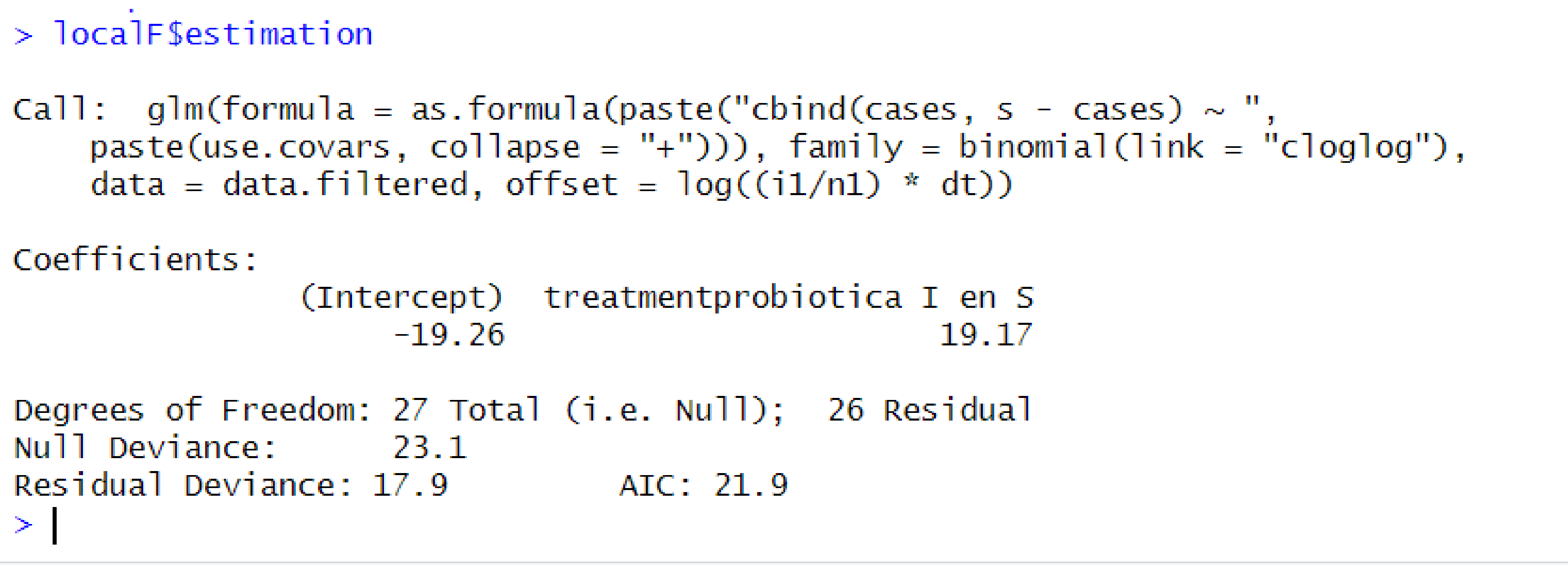
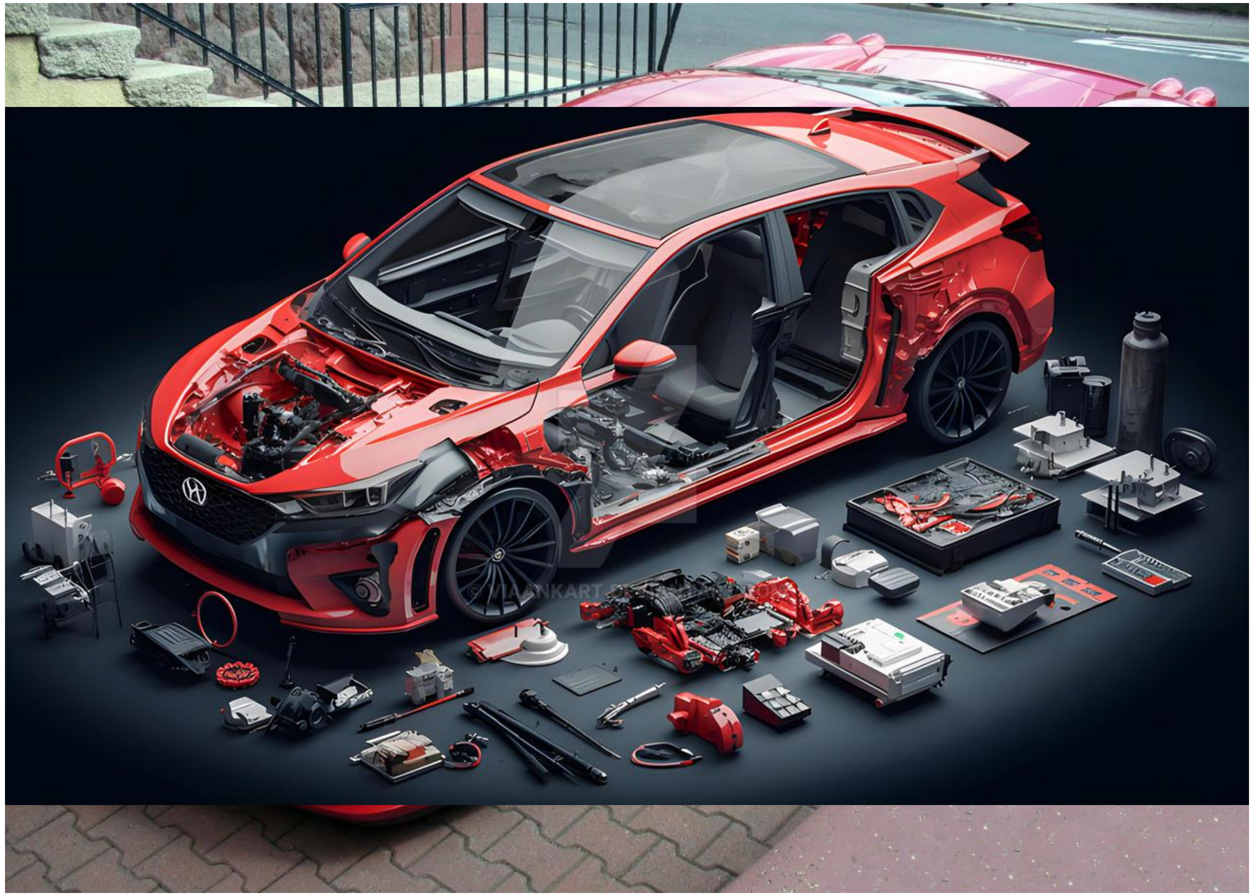


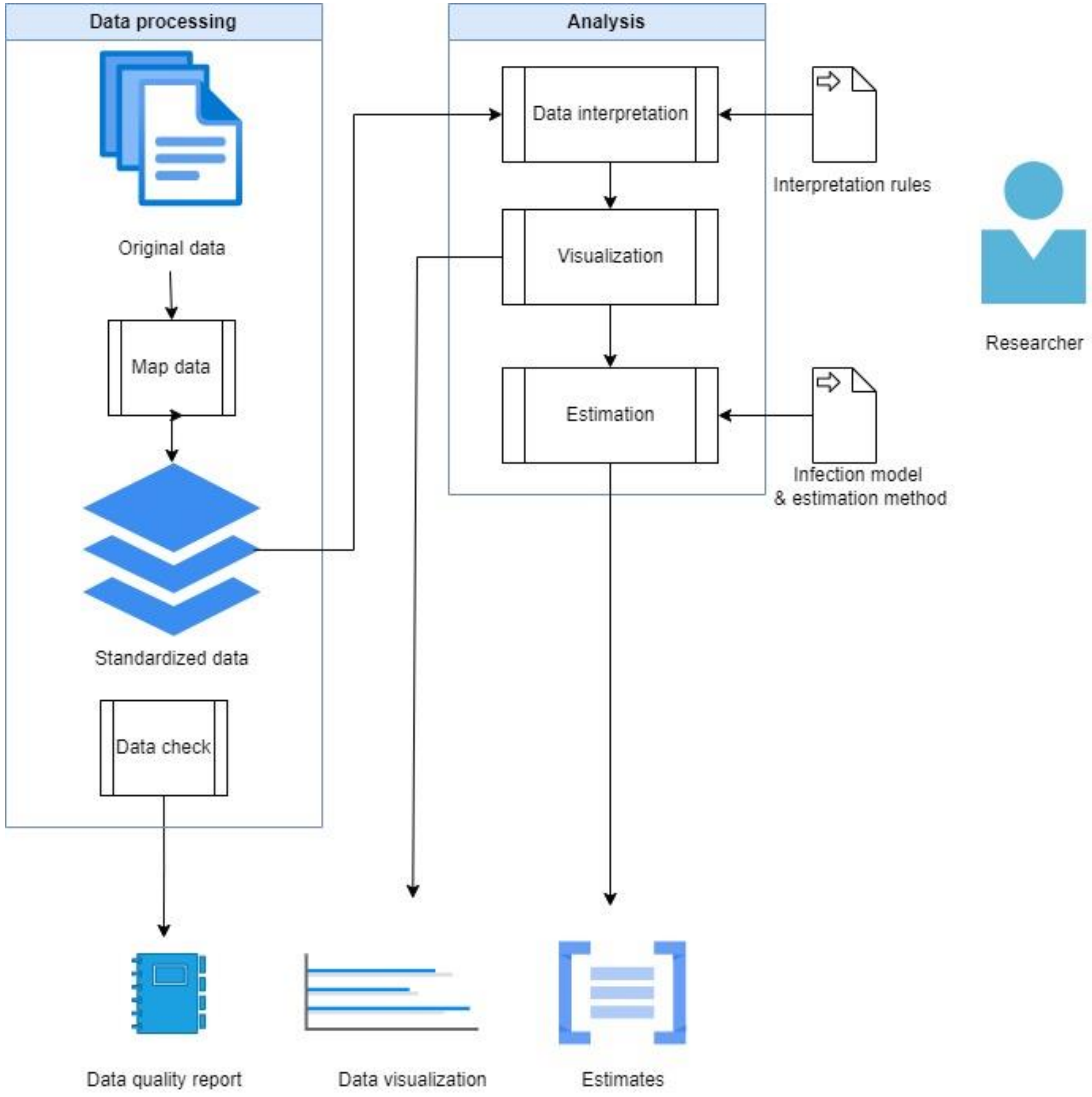
```
> localF$estimation

Call:  glm(formula = as.formula(paste("cbind(cases, s - cases) ~ ",
    paste(use.covars, collapse = "+"))), family = binomial(link = "cloglog"),
    data = data.filtered, offset = log((i1/n1) * dt))

Coefficients:
               (Intercept)  treatmentprobiotica I en S
                    -19.26                       19.17

Degrees of Freedom: 27 Total (i.e. Null);  26 Residual
Null Deviance:      23.1
Residual Deviance: 17.9        AIC: 21.9
> |
```

Work in progress



Discussion

- Data standardization
- Data interpretation
    - Automated
    - Documented
    - Reproducible
- Estimation
    - Reproducible
    - Reusable
- Adaptable code



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Sharing science,
shaping tomorrow

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https://github.com/UtrechtUniversity/autumn-fair/blob/main/docs/SummerFAIR_schema_proposal_V04.pdf

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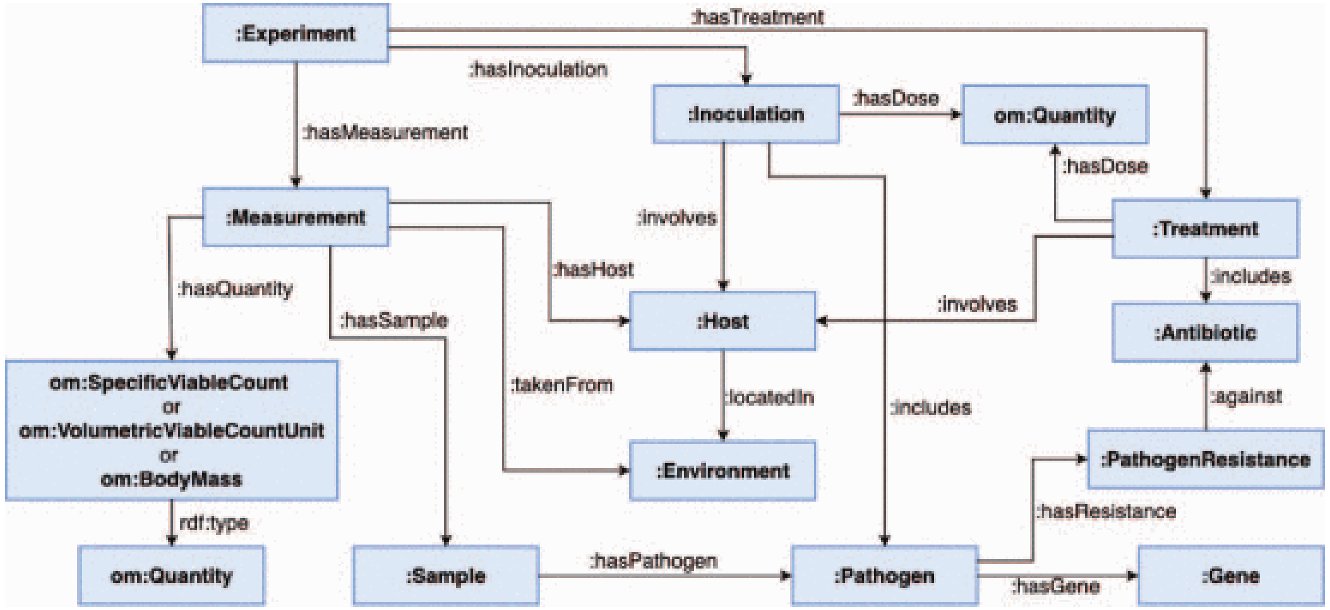

Infection Transmission Ontology
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