Investigating decision accountability & trustworthiness

How fair were COVID19 restrictions?

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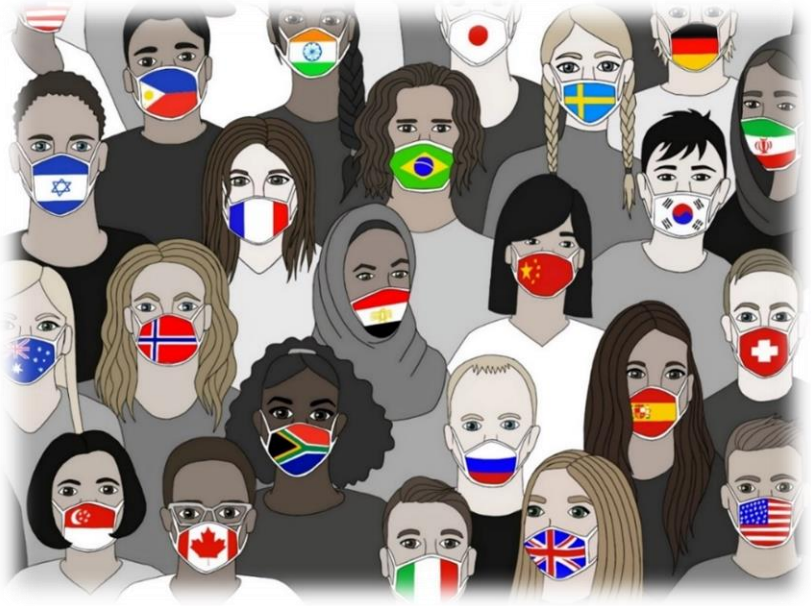
Covid-19 Restrictions

- Almost *7 million* confirmed Covid-19 Deaths[1]
- Countries reacted to Covid-19 differently
- But many locked down the whole country during *"1st Waves"*
- **As the pandemic progressed - Countries' responses evolved**



[1] https://covid19.who.int

UK Covid Tired System

- UK government tackled its *"2nd wave"* with a tiered system
- Different areas of England each assigned a ***Tier*** level 1-4

Tier 1 Tier 2 Tier 3 Tier 4

- Factors to determine tier level for each area:

Covid-19 cases all ages

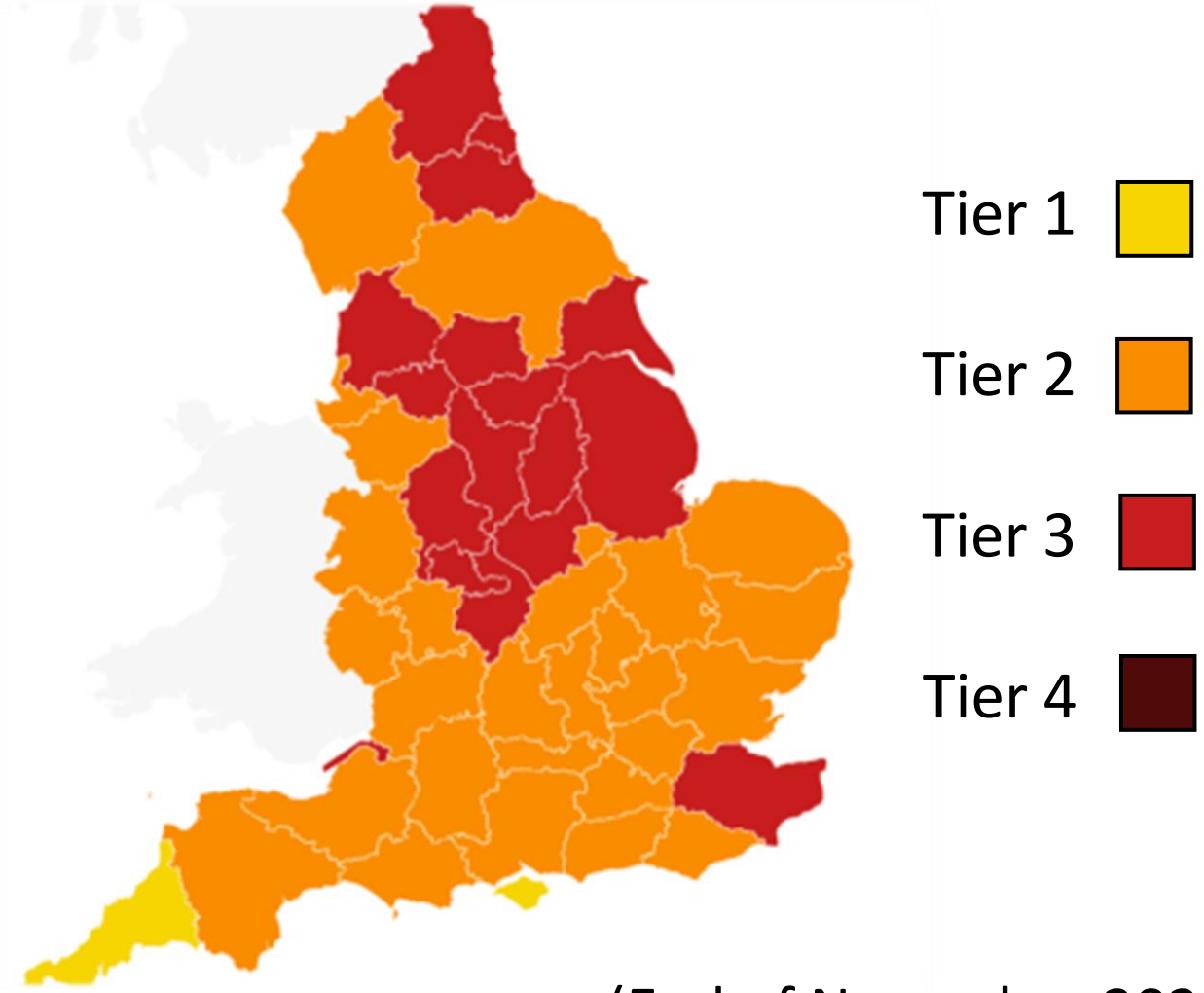
Cases as % of all tests

Covid-19 cases 60+ ages

Cases rising or falling

Pressure on health services

UK Covid Tired System



(End of November 2020)

How fair were COVID19 restrictions?

- Complaints of inconsistency and opacity in tier decisions

Dominance Based Rough Sets Approach (DRSA)

- Utilizing historic data relating to
  - Multiple criteria
  - Resulting decision (class label)

- **To produce set of *IF* → *THEN* rules of patterns in the data**

Observation	Number of Cases	Rate of change	Positivity Rate	Tier
x_1	195	2.48	8.05	3
x_2	92	2.45	7.89	2
x_3	237	-2.74	8.94	2
x_4	515	2.82	1.43	3
x_5	528	7.54	5.3	3
x_6	434	1.65	5.41	2
x_7	143	-3.15	8.01	1
x_8	75	3.2	5.25	2
x_9	269	2.33	1.71	1
x_{10}	131	3.28	1.03	1

Rough Sets Data Driven Analysis

- Set of Rules in the form of: ***IF → THEN***

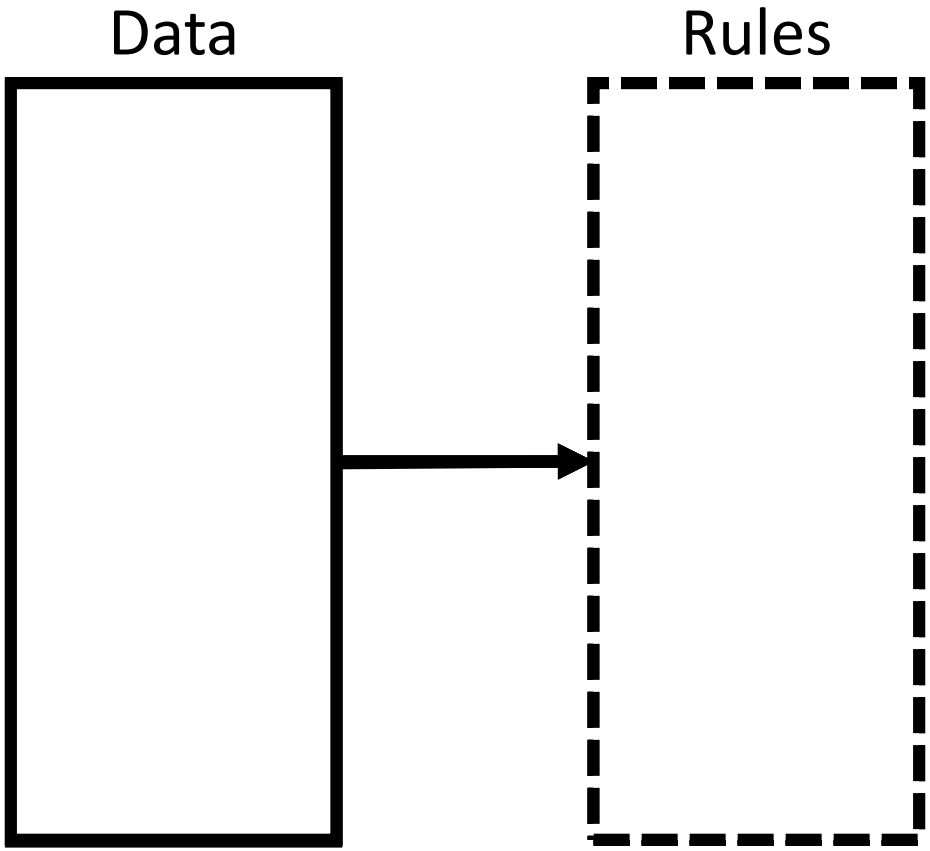
- Highlighting
  - Criteria thresholds that result in certain outcomes
  - Boundaries between possible decision outcomes

- ***IF "No. of Cases" > x : THEN → Tier 2 or more***
- ***IF "No. of Cases" > y : THEN → Tier 3 or more***

- Such ruleset results can be used for:
  - Insights and explainability
  - Determine classification outcome on new unseen data

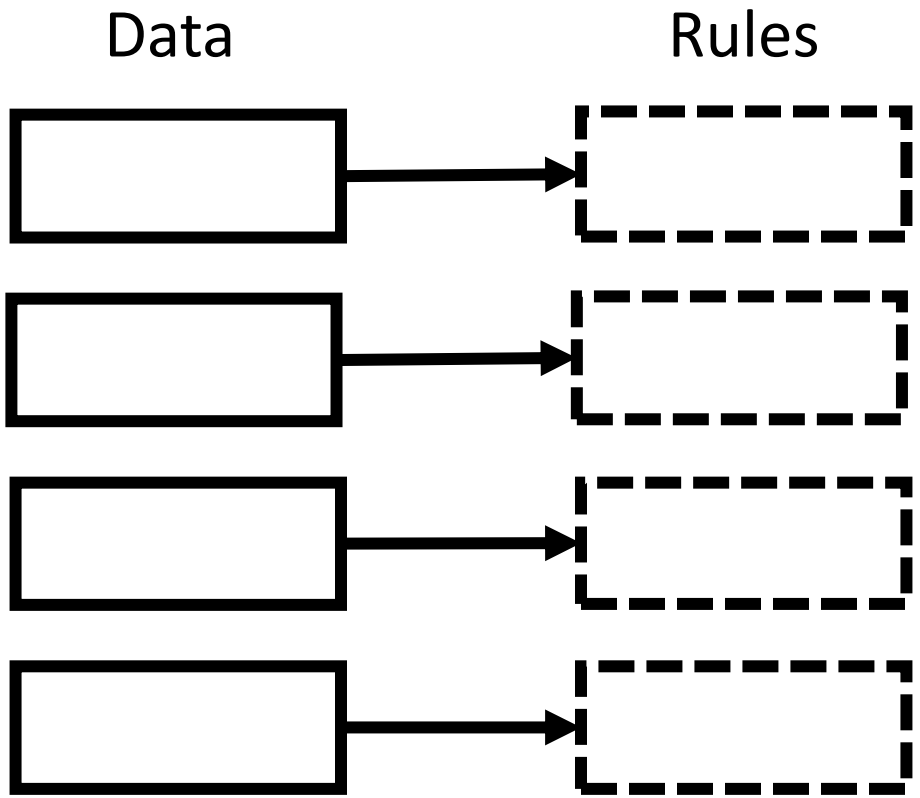
Rough Sets Data Driven Analysis

- Set of Rules in the form of: ***IF → THEN***
- ***IF "No. of Cases" > x : THEN → Tier 2 or more***



Rough Sets Data Driven Analysis

- Subset data into different geographical areas
- **Create separate rule sets from each data subset**



Comparison of different geographical areas' rules

Results

- Comparisons where different rulesets share the *“same rule”*

- **Relate to same criteria and resulted in the same tier level**

- **Area 1:** IF “No. of Cases” > ***x*** : THEN → TIER 3 or more
- **Area 2:** IF “No. of Cases” > ***y*** : THEN → TIER 3 or more

- Given consistent application of data driven approach
- And utilisation of just criteria data to make Tier decisions
- Should expect similar boundaries to move from Tier to Tier

Results

- Slicing overall dataset into segments:
  - “North” and “South” of England
  - “North”, “South without London”, and “London”
  - The 9 separate regions of England

- Comparison of rulesets
- Find *shared rules*
- Collate together all shared rules

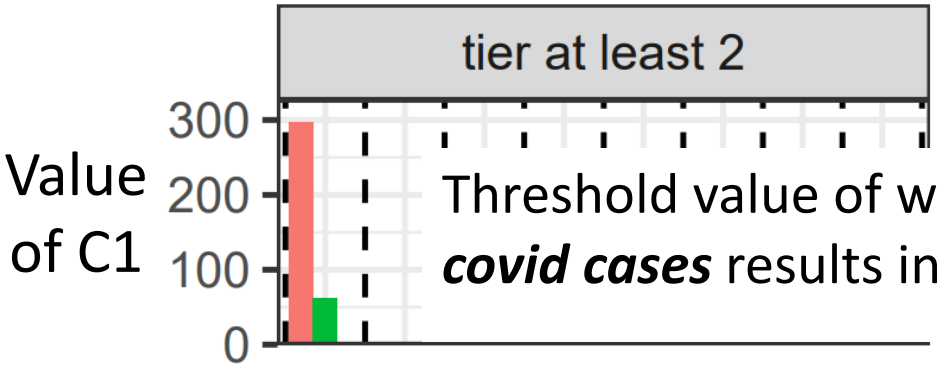
Results

- Slicing as: “North”, “South without London”, & “London”

London

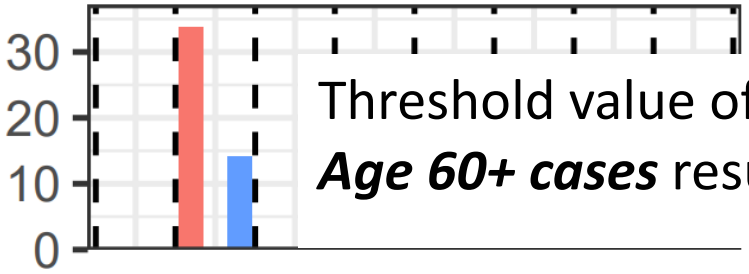
North

South



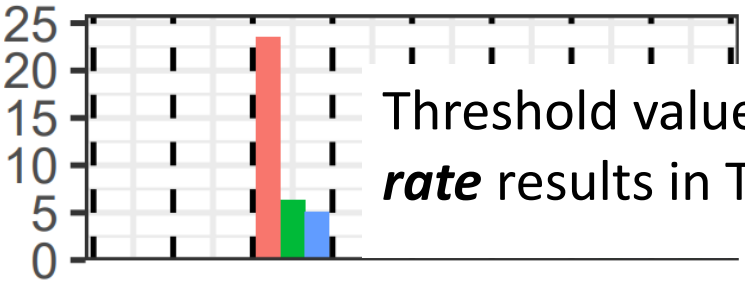
Value of C1

Threshold value of when ***number of covid cases*** results in Tier 2 or more



Value of C2

Threshold value of when ***number of Age 60+ cases*** results in Tier 2 or more



Value of C4

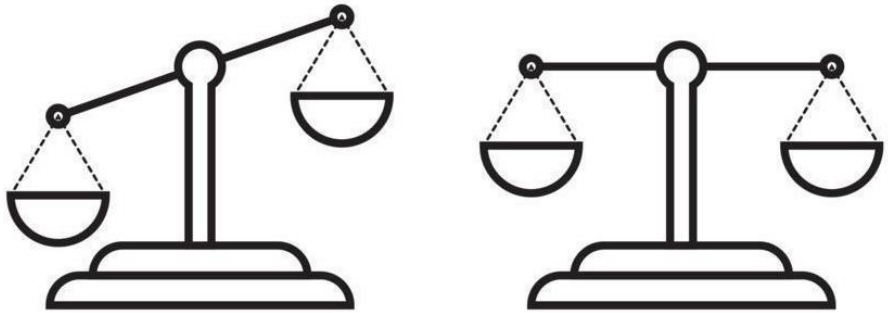
Threshold value of when ***positivity rate*** results in Tier 2 or more

Results

- Overall inconsistency between North & South of England
- **Suggesting the south treated more leniently**

- Drilling down inconsistency driven mostly by London
- **Suggesting London specifically treated more leniently**

- Suggesting…
  - Inconsistent utilization of the data to derive decisions?
  - Additional implicit criteria? (e.g., economic concerns)

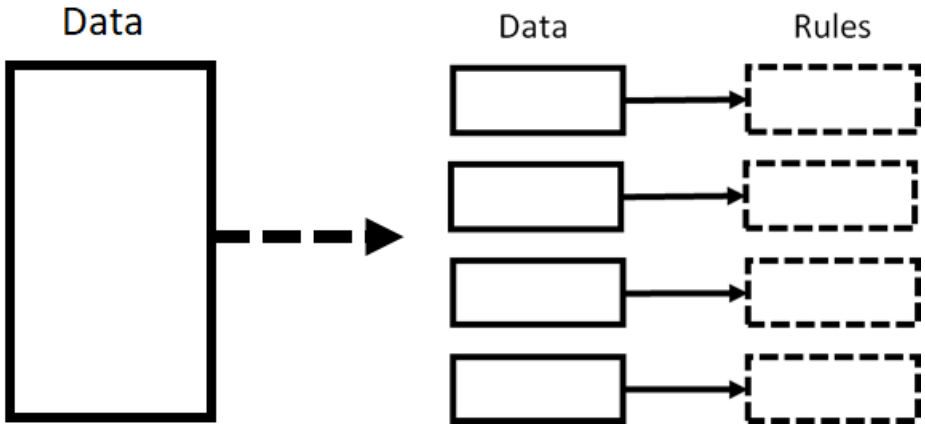


DRSA for Fairness Analysis

- **Here we explored our approach for evaluating the fairness of the UK's Covid Tired restriction of movement system**

- Approach could be utilised to explore fairness in other domains

- **Slicing data by attribute that should not be impacting decisions**
  - *For our covid data the attribute of geographical area*
  - Age in recruitment decisions
  - Gender in Examination Grade



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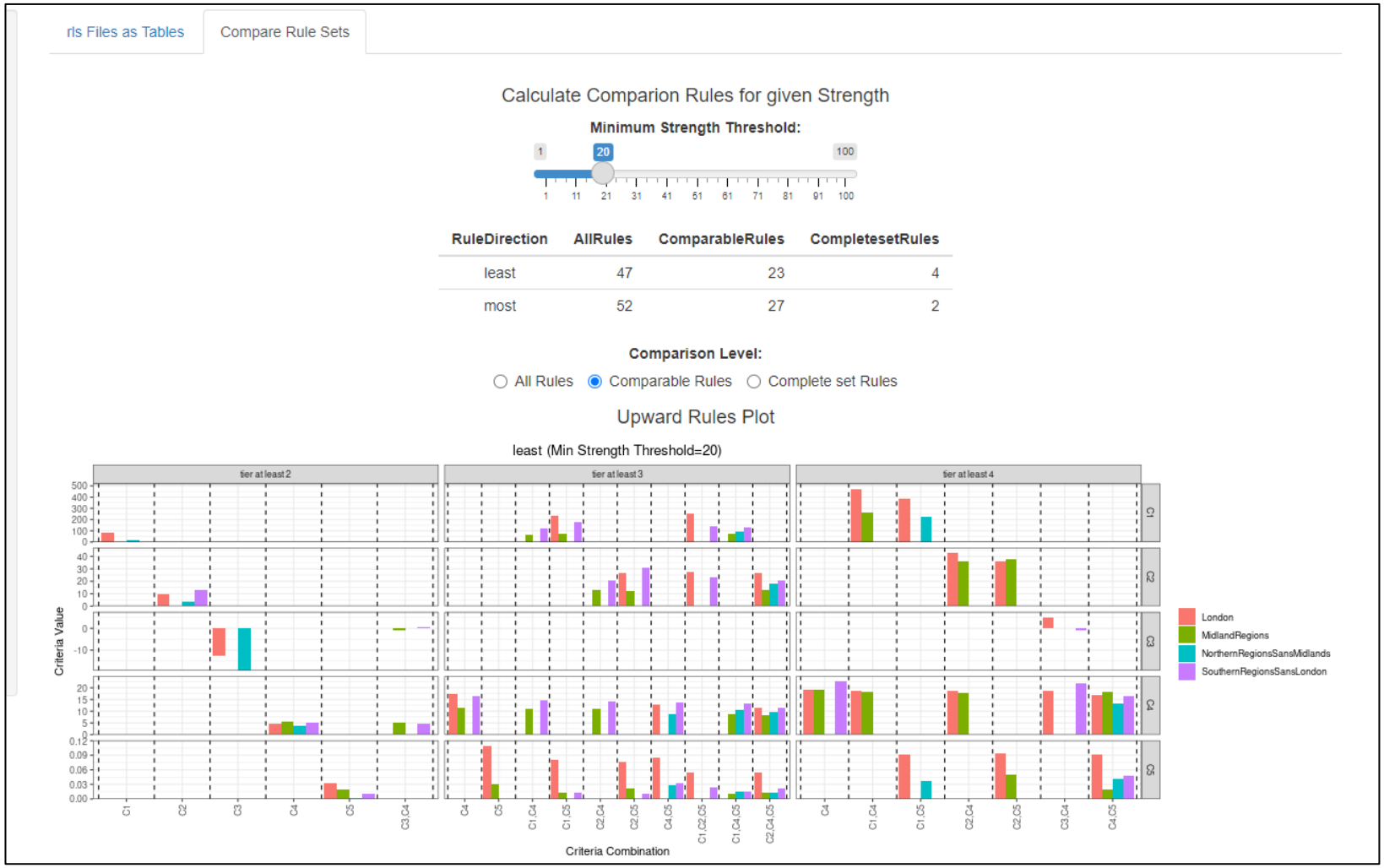
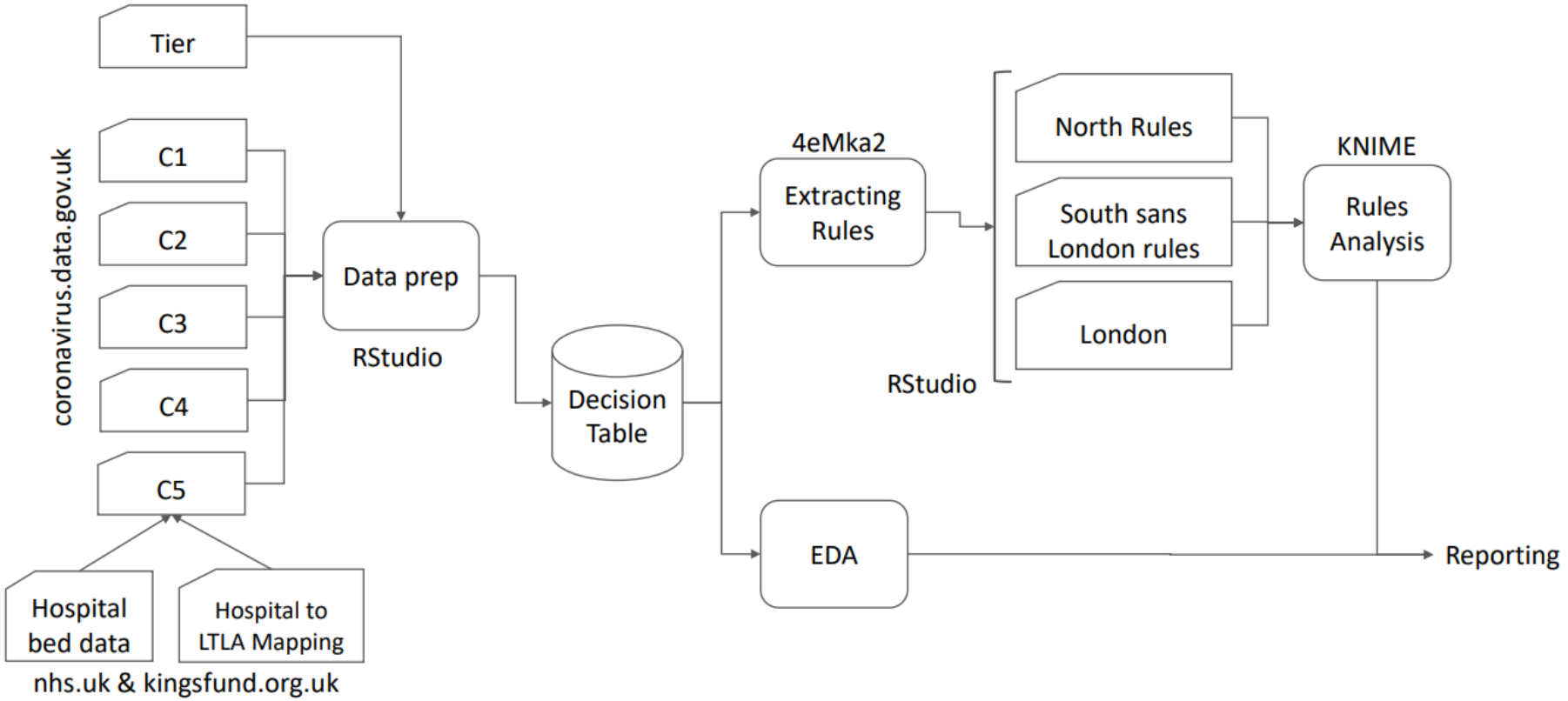
Interactive Decision Tool

- Future work exploring interactive user tool
- Interactively define slicing – attribute and value subsets etc.

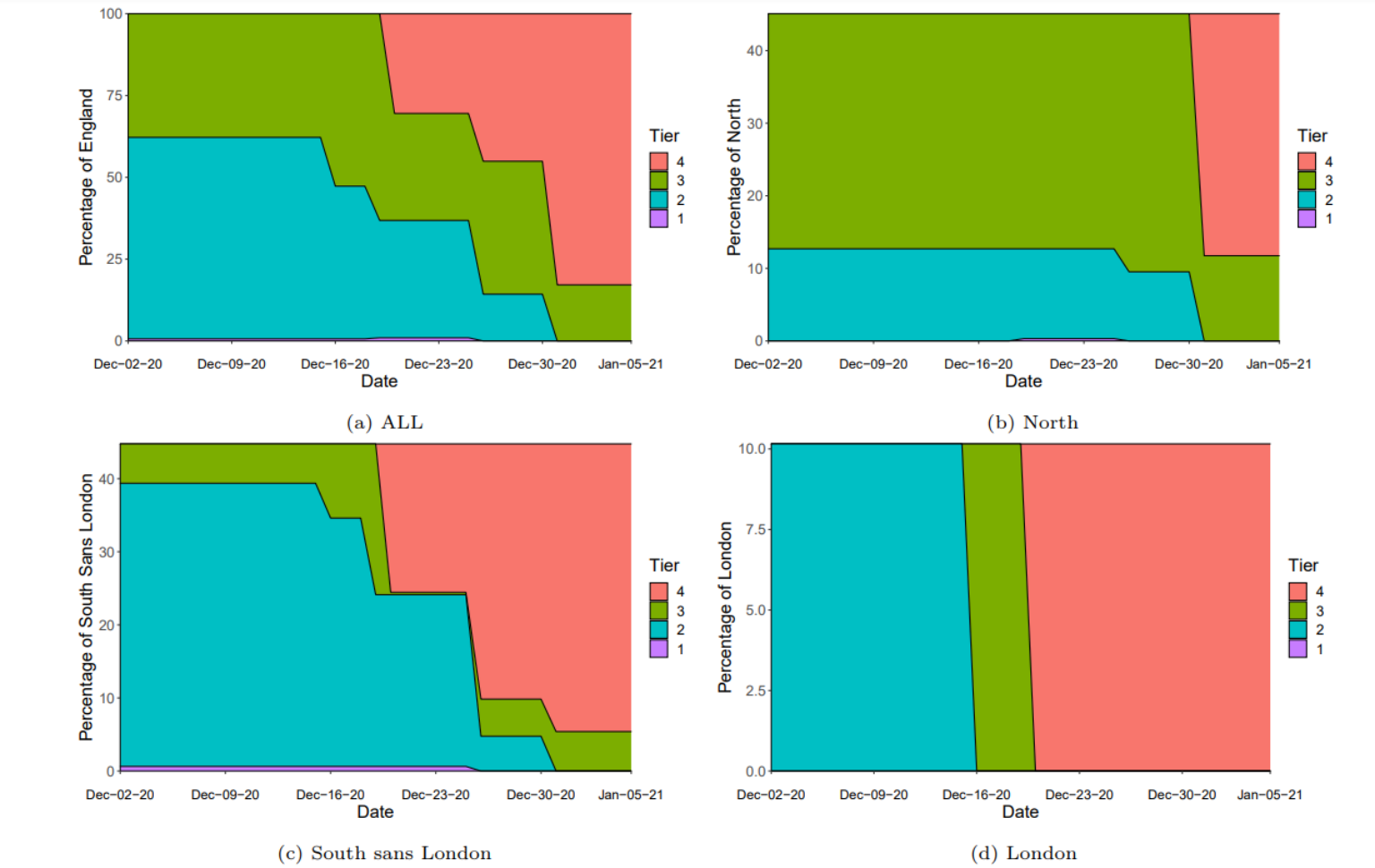


Data Pipeline



Data Sparsity

- Disjointed coverage of Tiers in data – overall and in region segments
- Less resulting comparable rules – than domains with higher coverage

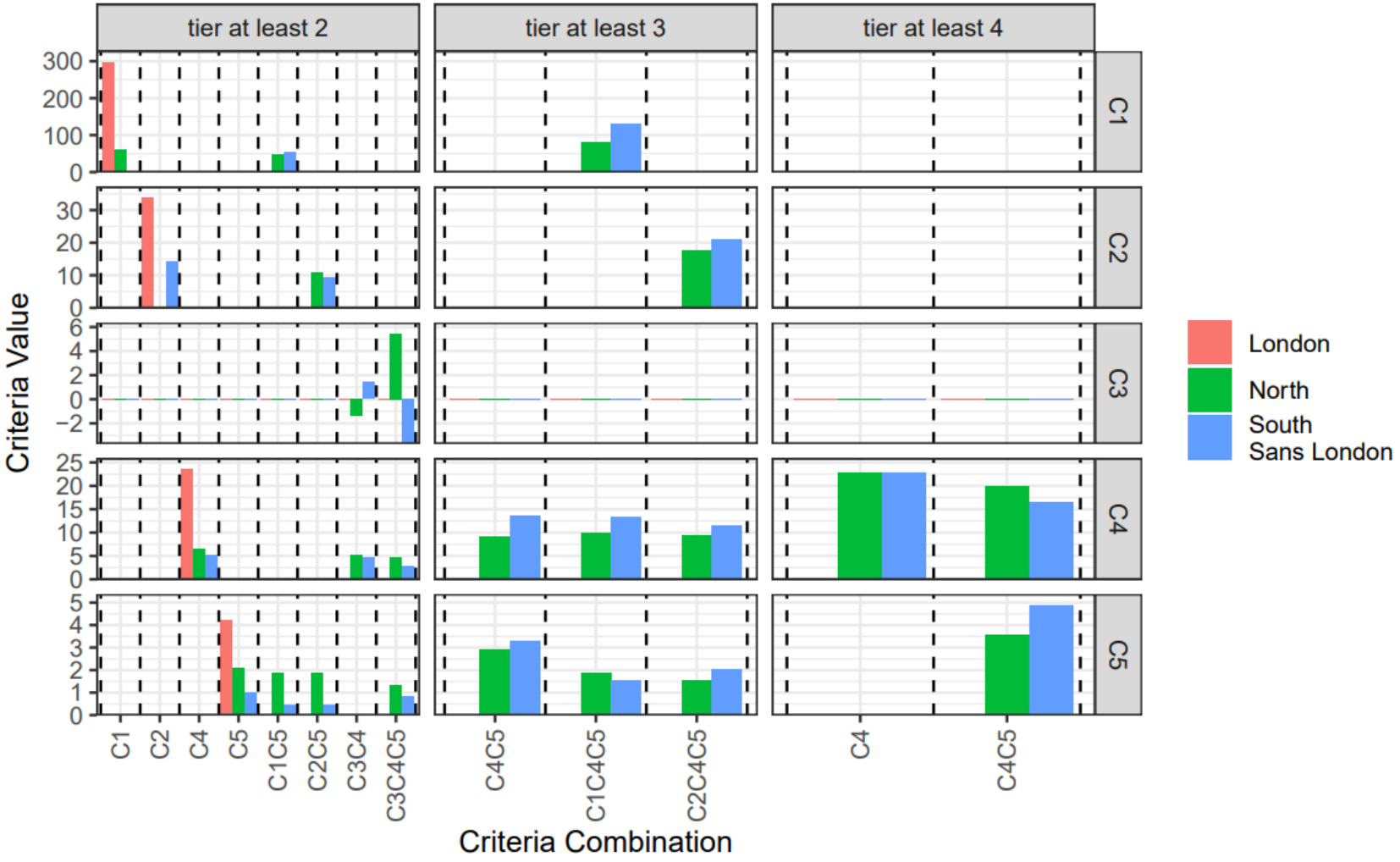


(a) ALL (b) North

(c) South sans London (d) London

At Least Results – Upward rules

- North, South without London, and London



Representative Rules

- In reality may have the “same” rule multiple times in a ruleset
- *Just with different strengths (and different criteria values)*

London Ruleset Extract

Antecedent	Consequent	Strength
(Number of Cases >= 160) and (Positivity Rate >= 13.8)	at least T2	27.76
(Number of Cases >= 166) and (Positivity Rate >= 13.7)	at least T2	33.5
(Number of Cases >= 180) and (Positivity Rate >= 29.6)	at least T2	62.67
(Number of Cases >= 180) and (Positivity Rate >= 28.2)	at least T2	73.02
(Number of Cases >= 184) and (Positivity Rate >= 27.6)	at least T2	77.76

- Aggregation of such rules into a single “representative rule”
- **Via weighted averaging proportional to the rule strength**
- Any other prominent aggregation approach could be used

- Facilitates then having 1-1 comparisons between rulesets

Representative Rules

London Ruleset Extract

Antecedent	Consequent	Strength
(Number of Cases >= 160) and (Positivity Rate >= 13.8)	at least T2	27.76
(Number of Cases >= 166) and (Positivity Rate >= 13.7)	at least T2	33.5
(Number of Cases >= 180) and (Positivity Rate >= 29.6)	at least T2	62.67
(Number of Cases >= 180) and (Positivity Rate >= 28.2)	at least T2	73.02
(Number of Cases >= 184) and (Positivity Rate >= 27.6)	at least T2	77.76

Region	Antecedent	Consequent
London	(Number of Cases => 177.40) and (Positivity Rate => 25.13)	at least T2
North	(Number of Cases => 146.04) and (Positivity Rate => 19.09)	at least T2

The North Ruleset Extract

Antecedent	Consequent	Strength
(Number of Cases >= 142) and (Positivity Rate >= 12.1)	at least T2	28.5
(Number of Cases >= 140) and (Positivity Rate >= 13.1)	at least T2	34.5
(Number of Cases >= 151) and (Positivity Rate >= 25.3)	at least T2	65.4