Difference in differences analysis evaluates the effects of the badger control policy on bovine tuberculosis in England

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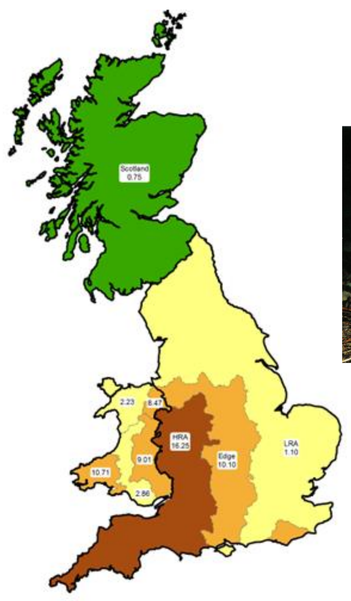
Bovine tuberculosis (bTB) in Great Britain

- Bacterial disease, *Mycobacterium bovis.*
- Disease of mammals, including cattle and humans.
- Active surveillance – field test & slaughterhouse.
- Unevenly distributed – highest levels in parts of south-west and west England and Wales.
  - Scotland officially bTB free.
- High prevalence with test, restrict and slaughter control causes costs and hardship for farmers.
- During 12 months to March 2023 in England[1]:
  - 7,840,000 cattle tests
  - 2,710 new herd restrictions for bTB
  - 20,200 cattle slaughtered
  - 8.3% prevalence in England High Risk Area.



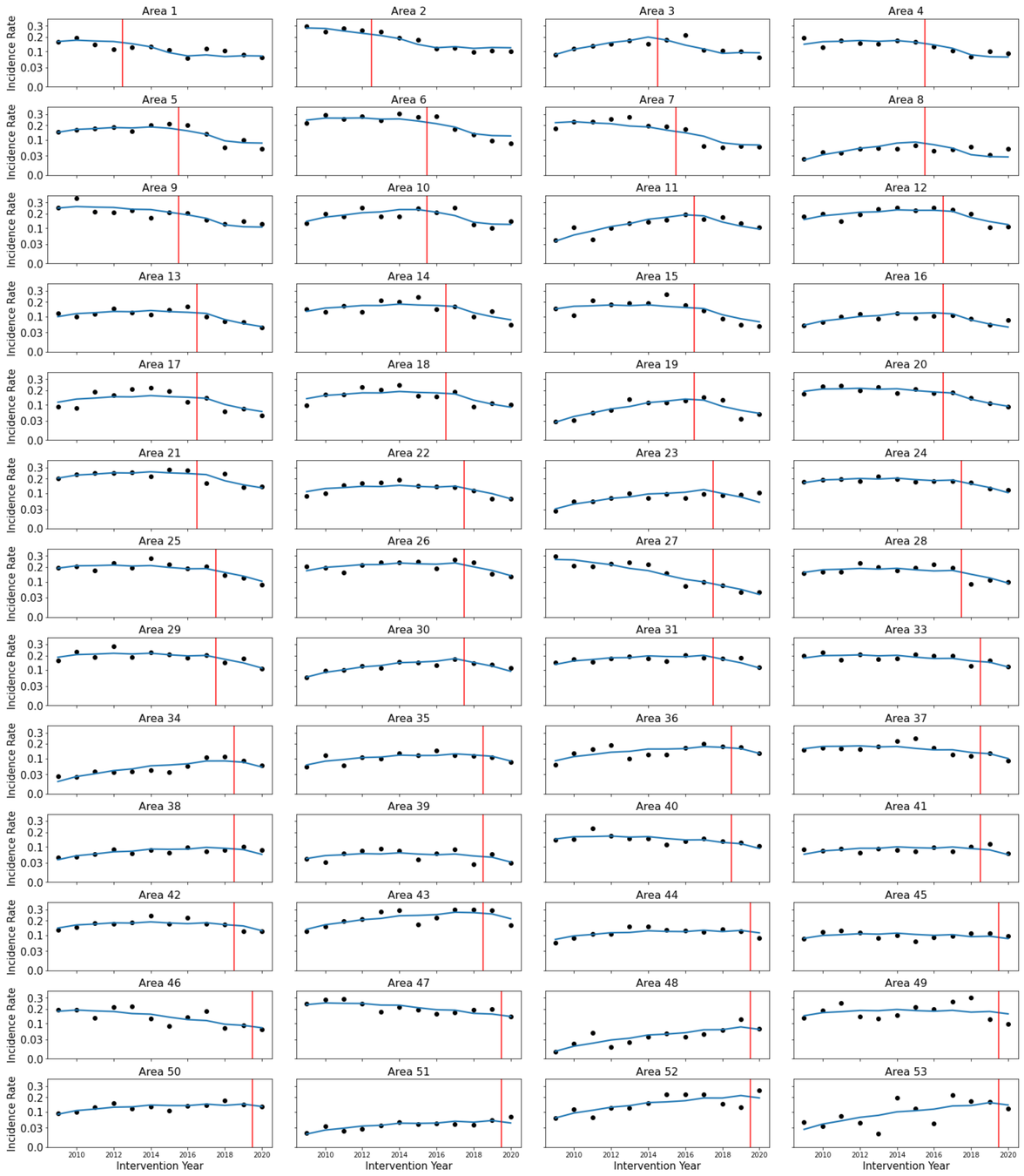
Bovine tuberculosis and badgers in Great Britain

- bTB infects various wildlife, including badgers.
  - Badgers suspected reservoir since 1970s.
- Genetic and epidemiological evidence of bTB infection shared between cattle and badgers.
- Randomized Badger Culling Trial (RBCT 1998-2005)[2]:
  - Reduced bTB incidence in cattle within trial areas.
  - Mixed interpretation.
- Badgers are a protected species: resistance to culling.

Badger Control Policy (BCP) in England

- Objective: reduce bTB incidence rate in cattle by reducing exchange of infection with badgers.
- Target: reduce badger population in BCP areas by 70%.
- Pilots from 2013, rapid rollout from 2016.
- Culling licences issued for discrete areas 200 to 1600 km².
- At least 4 annual rounds of culling completed in each area.
- Also included additional surveillance tests in detected infected herds.
- Up to 2020, 52 BCP areas started in high bTB incidence regions.
- Up to end of 2022, BCP included > 90% high bTB incidence areas in England.

Year	Number of BCP areas in HRA and Edge Area
2013	2
2014	2
2015	3
2016	10
2017	21
2018	31
2019	42
2020	52



Comparison of the statistical model (blue line) to observed incidence rate i.e. confirmed incidents per herd year at risk (black dots) for each area. The red line represents the start of the BCP in that area.

Objective: Evaluate the effect of Badger Control Policy on bTB incidence rate in cattle

- Expansion prevented comparison of BCP areas with unculled control areas.
  - In any case, definition of control areas would be challenging.
- BCP licences precisely define 52 distinct areas.
  - Equivalent: all entered BCP.
  - Entered BCP in different years.
- Data available before and after start of BCP in every area.
- A linear model with fixed effects can estimate effect of each year of BCP interventions by Difference in Differences.
- A linear model was preferred to a Poisson GLM.
  - Incidence rate was more suitable than counts for reporting.
  - Areas have a wide range of size.

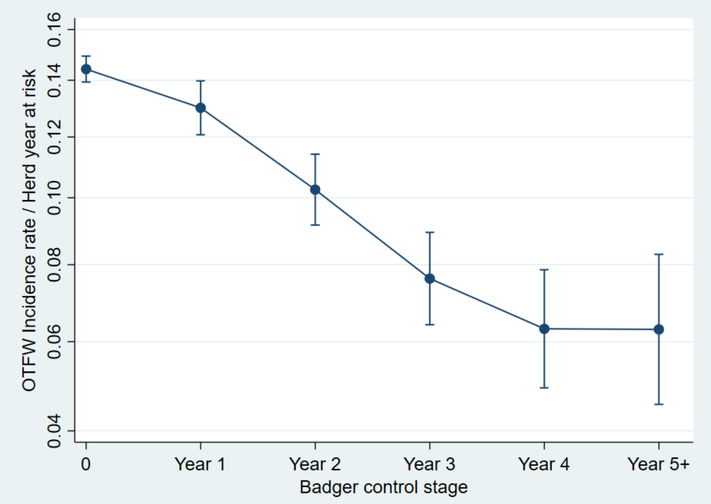
Definition of Statistical Model

- Observations were of Incidence Rate.
  - Counts of confirmed (certainly infected) incidents / area / year
  - Standardized by time at risk (herd years / area).
- Square-root transformation improves homogeneity of variance.
- Time units = intervention years (September – August).
- Linear model:

$$\sqrt{\text{Incidence rate}_{i,j}} = \text{Area}_i + \text{Year}_j + a_i * \min(j, s_i) + \text{BCP}_{i,j}$$

- i = 1..52 Areas; j = 1..12 years.
- a_i = slope coefficient in area i. Constrained so $\sum a_i = 0$.
- s_i = the year before start of BCP in area i.
- BCP at 6 levels for: before BCP, years 1, 2, 3, 4 and after 4 years
- Data are complete and balanced for Area and Year.

Estimated effects of the Badger Control Policy



Linear predictions from the statistical model of the confirmed (OTFW) incidence rate related to local duration of badger control policy for each intervention year.

- bTB incidence rate in cattle associated with duration of BCP interventions.
- Small reduction in first year; larger reductions in second and third years.
- Reductions beyond third year were slower.
- From linear predictions of expected incidence rate:
  - Incidence rate without BCP interventions = 0.145.
  - Incidence rate in fourth year of BCP = 0.06.
  - Estimated effect = 56% reduction of incidence rate in fourth year.
- Consistent with previous published estimates of effect of badger culling.
- Most precise estimate of timing of effects of badger controls.
- Poisson GLM of counts estimated similar effects of BCP.

References

[1]Bovine TB Statistics: https://www.gov.uk/government/collections/bovine-tb

[2]Donnelly et al, 2007. Int J Infect Dis, 11:300-8

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