Modelling the effect of climate on antimicrobial resistance prevalence and its application to UK dairy systems

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BACKGROUND

Climate change and AMR; 2 key global public health threats. But could climate change amplify and accelerate AMR?

- Increased bacterial infections
- Food insecurity
- Mass migration → pressure on environments
- **Increased temperature?**

Possible reasons:

- Bacterial growth rate
- Fitness cost of AMR
- Horizontal gene transfer
- Co-selection with stress response genes

Temperature → ? → Antimicrobial resistance (AMR)

Evidence for an association:**

- Population level studies – warmer climates have a higher prevalence of AMR infections in humans
- Environmental microbiomes – increased AMR genes at warmer temperatures

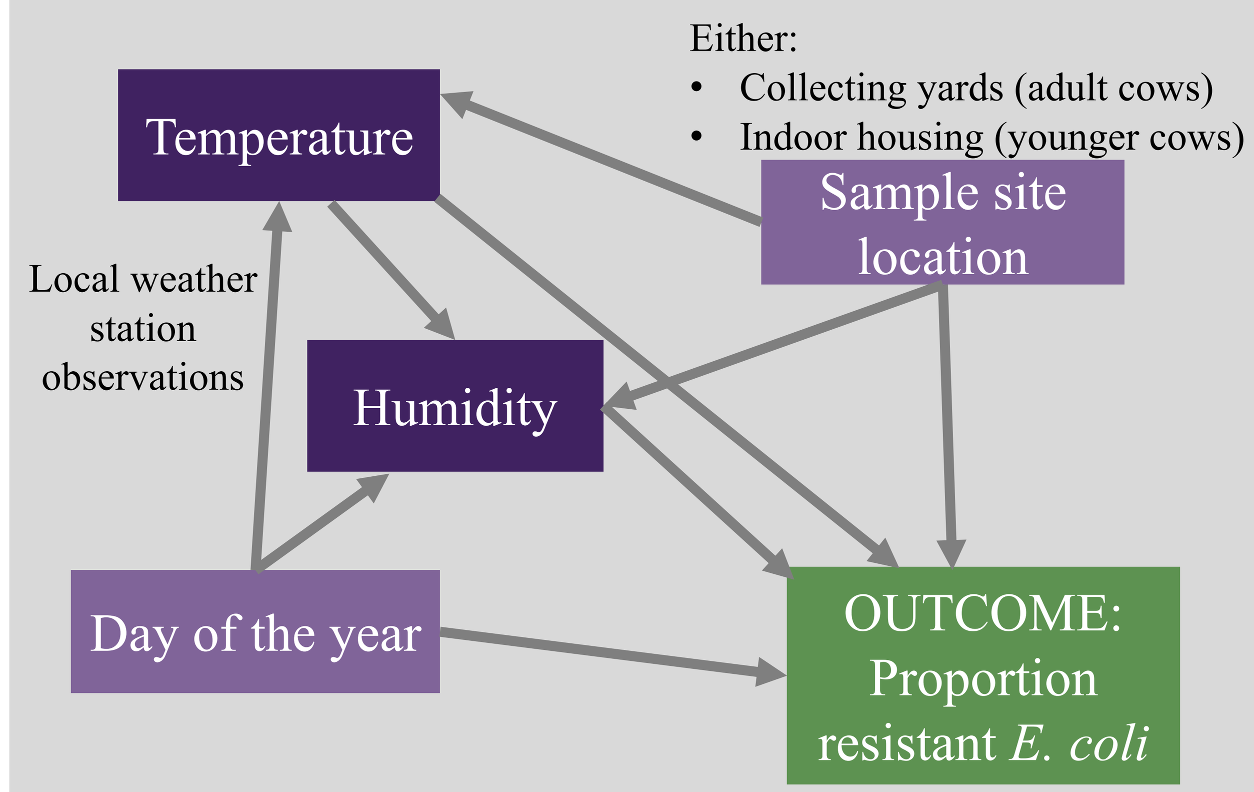
METHODS

OH-STAR study – farm environment sampling*

- Faecally contaminated samples were collected from the environment of 53 English dairy farms for 2 years
- The proportion of resistant *E. coli* was determined by culturing on on selective media containing 1 of 4 different antimicrobials (amoxicillin, cephalexin, streptomycin, and tetracycline) in addition to an antimicrobial-free plate to estimate *E. coli* abundance.

Statistical modelling

- Developed a novel modelling approach which estimated *E. coli* colony counts from two Poisson likelihoods (Bayesian approach)
  - This allowed for the uncertainty around the proportion of resistant *e. coli* to vary dependent on *E. coli* abundance, normalising for this
- Tensor product splines – model splines for temperature, humidity and their interaction
- Spline for 'day of year' – seasonal effects not related to temperature/humidity



RESULTS

In general, results showed:

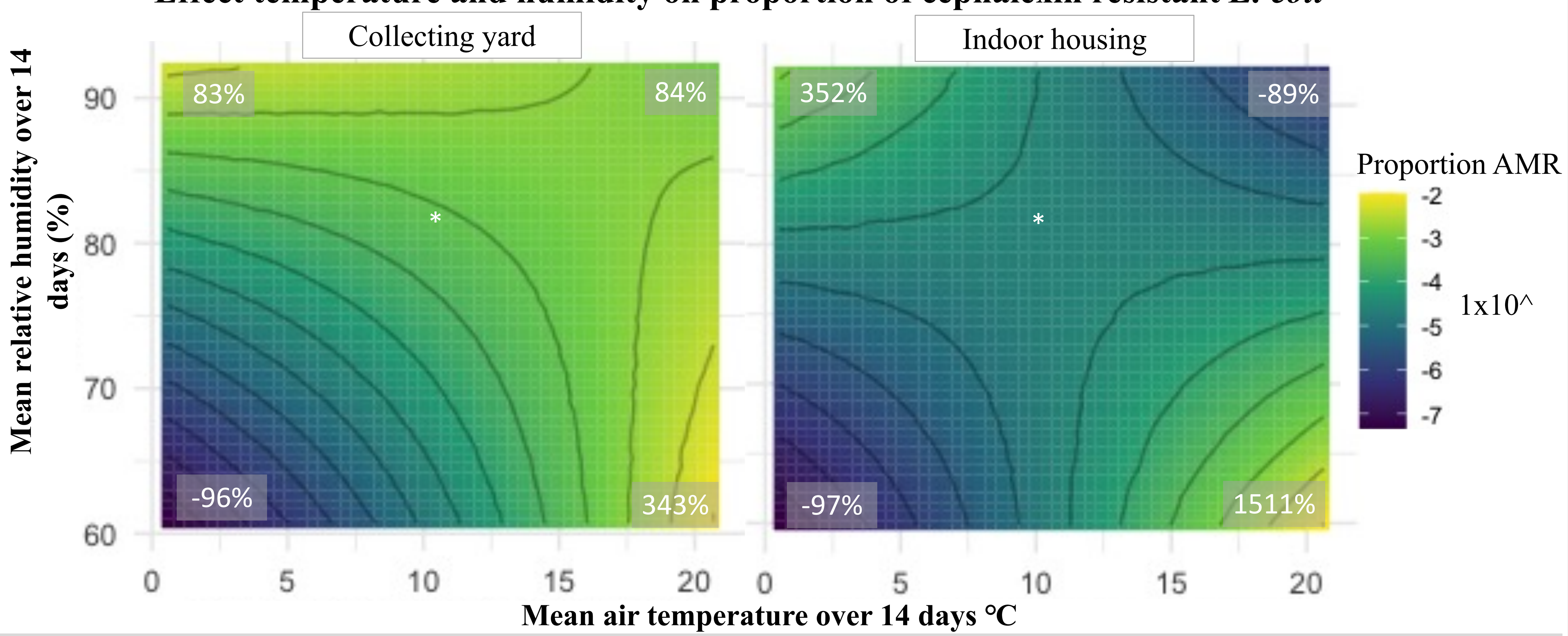
- ↑ Temperature ≈ ↑ AMR to all 4 AMs
- ↑ Humidity ≈ ↑ AMR to all 4 AMs

Effect size of temperature and humidity: Largest – cephalexin; Smallest - tetracycline

Interaction between temperature and humidity:

- \+ in collecting yard samples (more AMR in hot/damp conditions)
- − in indoor housing samples (more AMR in cold/damp and hot/dry conditions)

Effect temperature and humidity on proportion of cephalexin resistant *E. coli*



Although the mean proportion of resistant isolates was low overall (~1-2%), the change in proportion resistance was substantial. Labels show % change in the proportion of resistant isolates associated with change in temperature and humidity compared to the proportion of resistant isolates at the mean temperature and humidity for the study period (marked with *).

Key conclusions:

- Strong evidence that increased temperature and humidity are associated with increased AMR prevalence in the farm environment
- This impacts design of agricultural AMR surveillance – must test across seasons and measure bacterial abundance
- Potential for climate change to amplify the threat of AMR

Future studies:

- In order to provide stronger evidence, conduct a controlled experiment on one farm
- Reduce measurement error by measuring temperature and humidity at the sample point

*All data collection was carried out as part of the OH-STAR project (PIs: Kristen Reyher, Matthew Avison).

**Association of temperature and AMR in this study was first published in Schubert *et al.* 2021 (https://journals.asm.org/doi/10.1128/AEM.01468-20)