Climate Change:
A Ticking Lyme Bomb

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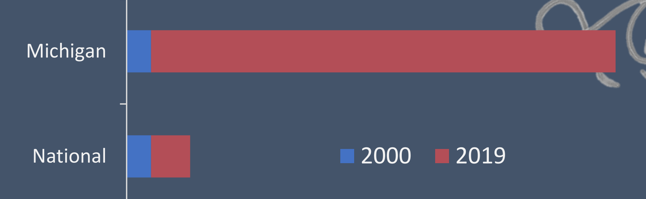
Background

What is Lyme Disease?

Lyme disease is caused by the bacterium *Borrelia burgdorferi*. It is transmitted to humans through the bite of infected blacklegged ticks. Typical symptoms include fever, headache, fatigue, and the characteristic "Bullseye Rash"

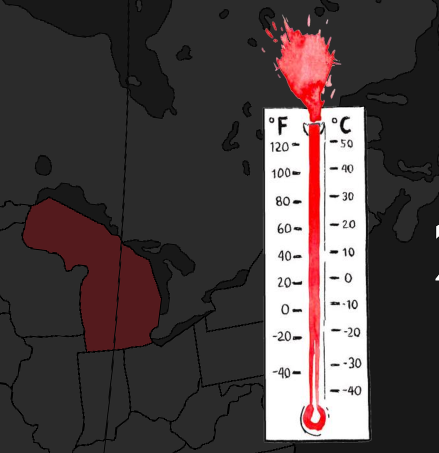


The incidence of Lyme disease in Michigan is growing faster than the national levels. **Why?**

The Black Legged Tick

- Two year life cycle
- Nymphs and adults carry and transmit *Borrelia burgdorferi*
- Questing ticks are found on low shrub branch tips
- **Ambient temperature** determines tick's ability to seek hosts
- **Relative humidity** determines how long the tick can quest for a bloodmeal, before returning to the ground to rehydrate

Compared to 20 years ago, Michigan has seen...



14% More rain

2.2x More extreme heat days

28% More extreme precipitation days

Is climate change linked to higher Lyme incidence in Michigan?

Weather-impacts of **climate change** are associated with **higher risk of Lyme Disease** in Michigan

Data

County-level Michigan data between 2000-2019

Collection
- MiTracking – Extreme heat & precipitation days
- CDC – Lyme incidence by county
- NOAA – Annual temps & rainfall

Wrangling
- Pandas python library

Analysis
- Linearmodels & Matplotlib python libraries

Methods

Fixed Effects Linear Panel Regression

$$Y_{it} = \beta C_{it} + \mu_i + \epsilon_{it}$$

Where:

Y_{it} = outcome of interest, incidence

βC_{it} = climatic variables

μ_i = unseen, county-specific, fixed effects

ϵ_{it} = error

Results & Implications

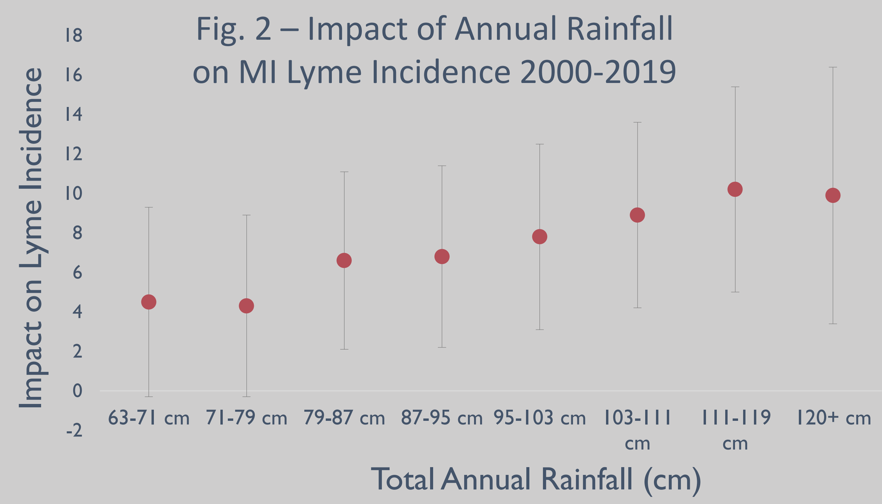
Fig. 1 – Impact of Climatic Variables on Lyme Incidence

Climatic Variable	Parameter	P-value
Extreme Heat Days	0.0647	0.0155
Extreme Precip. Days	-0.0275	0.8536
Total Rainfall	0.1481	0.000
Average Temp (F)	-0.1902	0.3337

R-square = 0.04 P-value = 0.000

This model accounts for 4% of the variation in 2000-2019 MI Lyme incidence. Total Annual Rainfall was the most significant factor, with a 14% increase in Lyme incidence for each additional cm of annual rain.

Fig. 2 – Impact of Annual Rainfall on MI Lyme Incidence 2000-2019



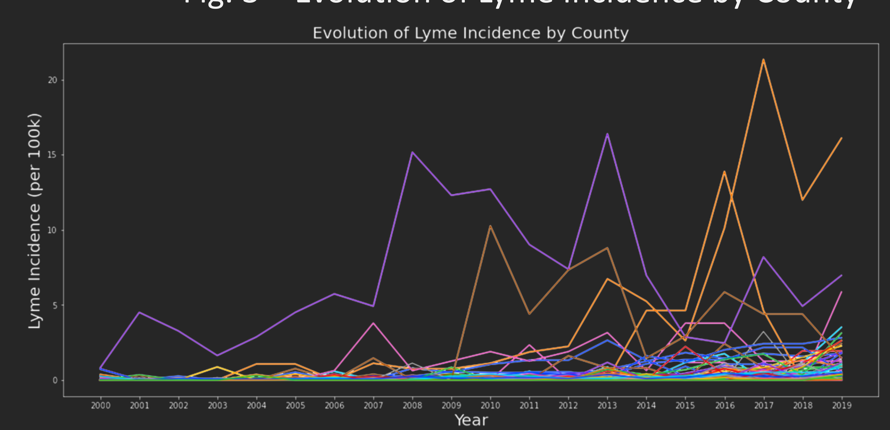
Total Annual Rainfall was binned into nine categories and modeled to illustrate progressively higher odds ratios as total rainfall increases. Risk is in reference to the smallest bin, >63cm

Total annual rainfall had the most significant impact on Lyme incidence, followed by annual extreme heat days

These results support Lyme incidence analyses done at the national level. Relations between a changing climate and increasing vector-borne illness is only one example of many complex downstream impacts impacting vulnerable populations today. Identification and characterization of climate change's harm is the first step towards public health's goal to provide equitable support to communities most impacted by climate change.

Moving forward, predictive climate change models may provide forecasting to support public health primary prevention efforts. These models may also identify impacted communities for public health mitigation efforts. Predictive climate change impact models may additionally help public health scientists formulate hypotheses for future studies and interventions.

Fig. 3 – Evolution of Lyme Incidence by County

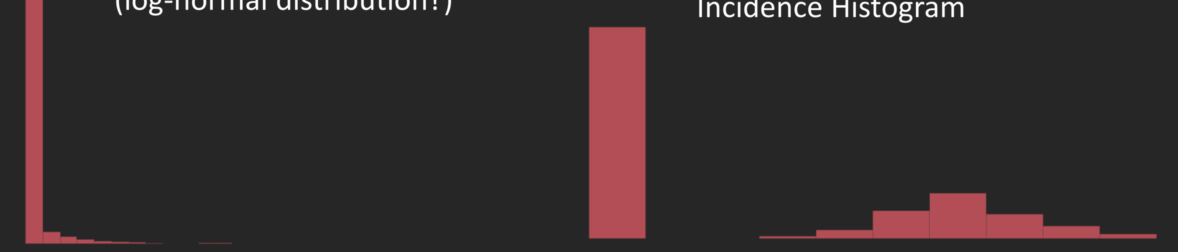


Rates of incidence change over 20 years differed among MI counties. Panel regression, also known as econometric modeling, regresses each county's repeated measures, and then generates the model with all individual regressions.

Fig. 4 – Transformation of Log-Normal Data

Annual County Incidence Histogram (log-normal distribution?)

Log-Transformed Annual County Incidence Histogram



The incidence data distribution is right-skewed, with many small values and zeroes. I log-transformed the data, adding 0.0001 to each value to account for the zeros. If Lyme incidence is truly log-normal, could I create a better regression model?

Fig. 5 – Log-Transformed Model

Climatic Variable	Parameter	P-value
Extreme Heat Days	0.0731	0.0000
Extreme Precip. Days	-0.0941	0.1063
Total Rainfall	0.1116	0.000
Average Temp (F)	-0.1736	0.0241

R-square = 0.09 P-value = 0.000

The log-transformed model explained twice the outcome variance, compared to the other model. It also illustrates potentially meaningful information about the other climatic variables, in particular, Average Temp (F)

Future Directions

- Is log-normalization appropriate for Lyme incidence in MI? What other modeling techniques might work better?
- Could data from a longer time period be located for more analyses?
- What other, non-weather related indicators of climate change may predict changes in vector-borne diseases?

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