

# Modelling the Ebola epidemic in West Africa

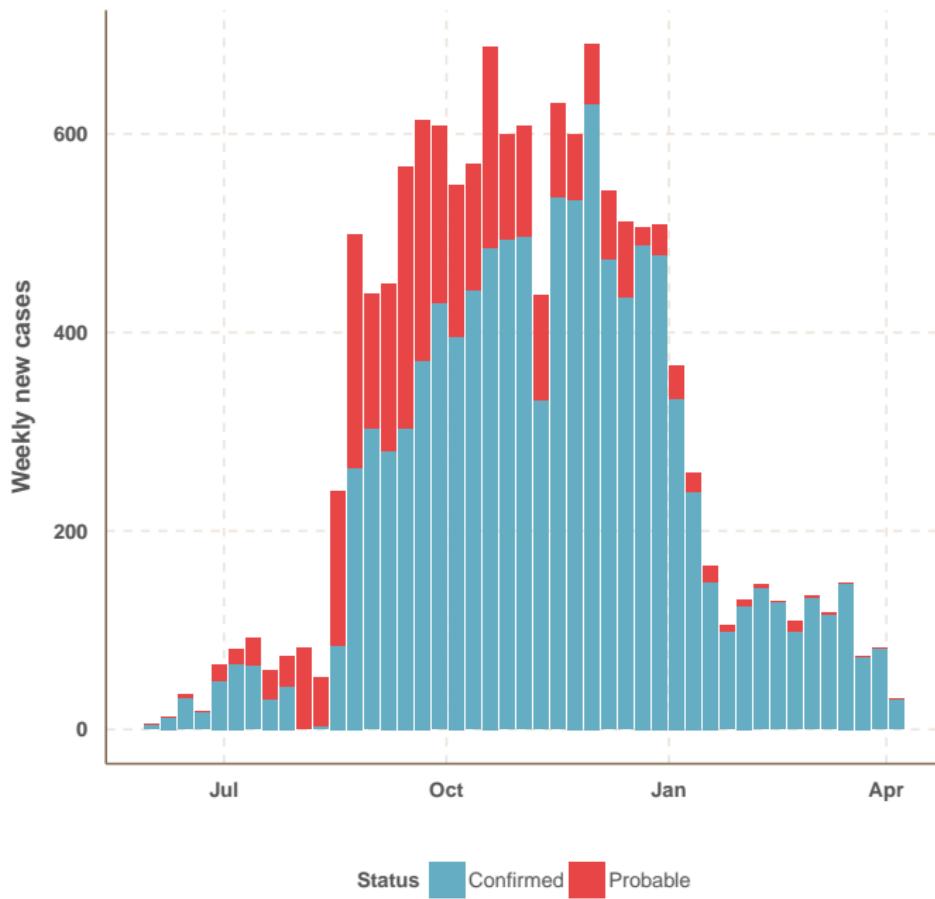
Centre for the Mathematical Modelling of Infectious Diseases  
London School of Hygiene & Tropical Medicine

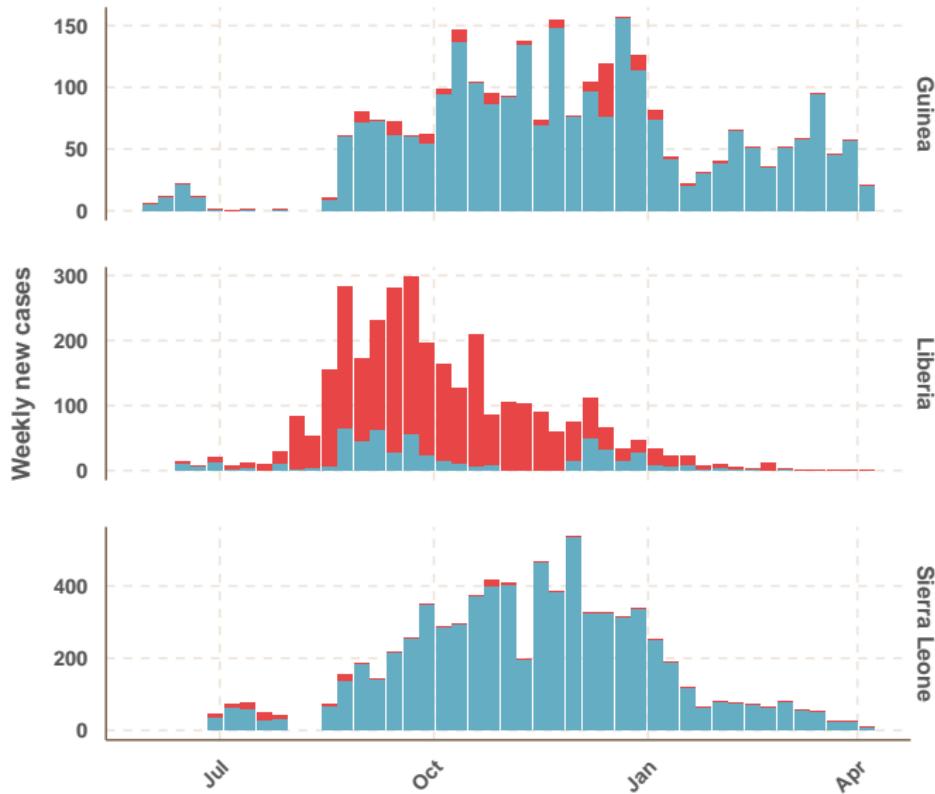
London  
School of  
Hygiene  
& Tropical  
Medicine



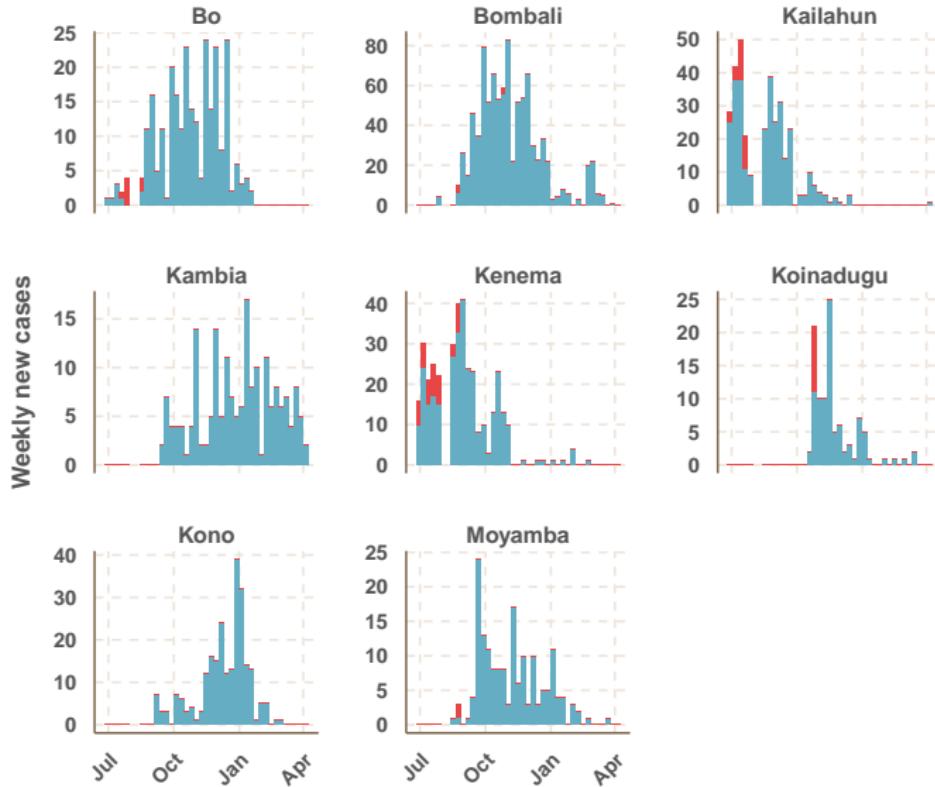
*centre for the  
mathematical  
modelling of  
infectious diseases*

# 1. Real-time modelling





Status    Confirmed    Probable

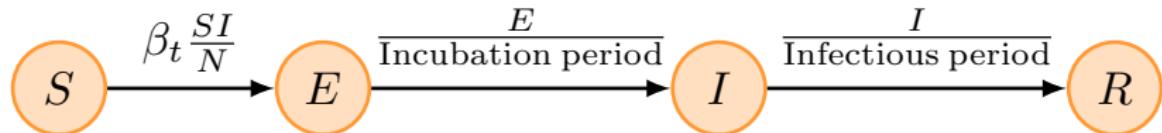


Status    Confirmed    Probable

## The unknown

- Community transmission
- Hospital transmission
- Funeral transmission
- Changes in behaviour
- Changes in reporting
- Interventions
- Seasonality
- etc

## The known



- Average incubation period (~9 days)
- Average infections period (~11 days)
- Case-fatality rate (~70%)

WHO Ebola response team, NEJM 2014

Transmission rate

stochastic process

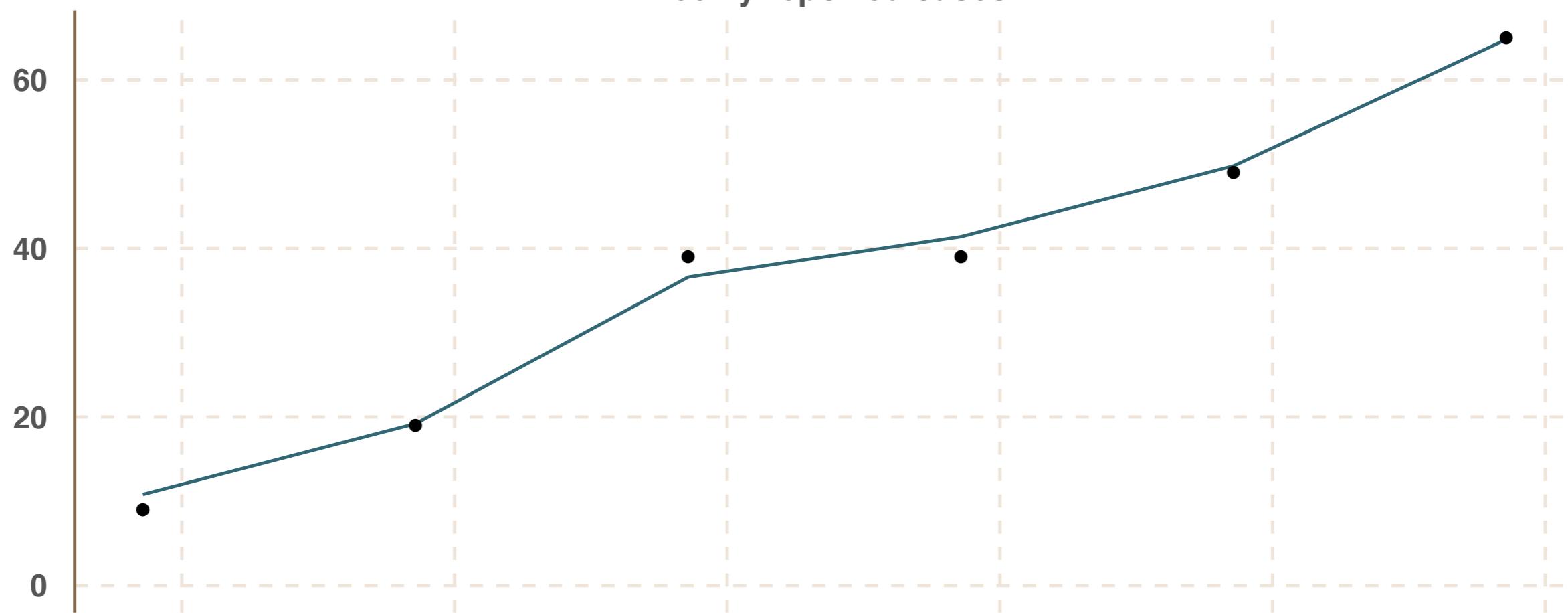
$$d\beta_t = \sigma dB_t$$



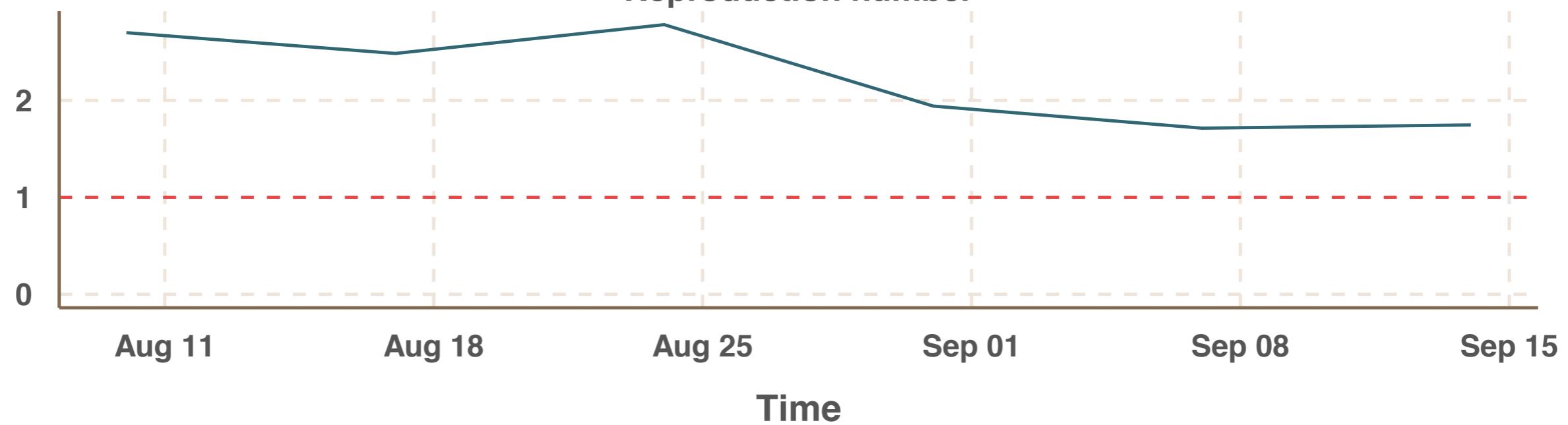
volatility

Dureau et al. (2013)

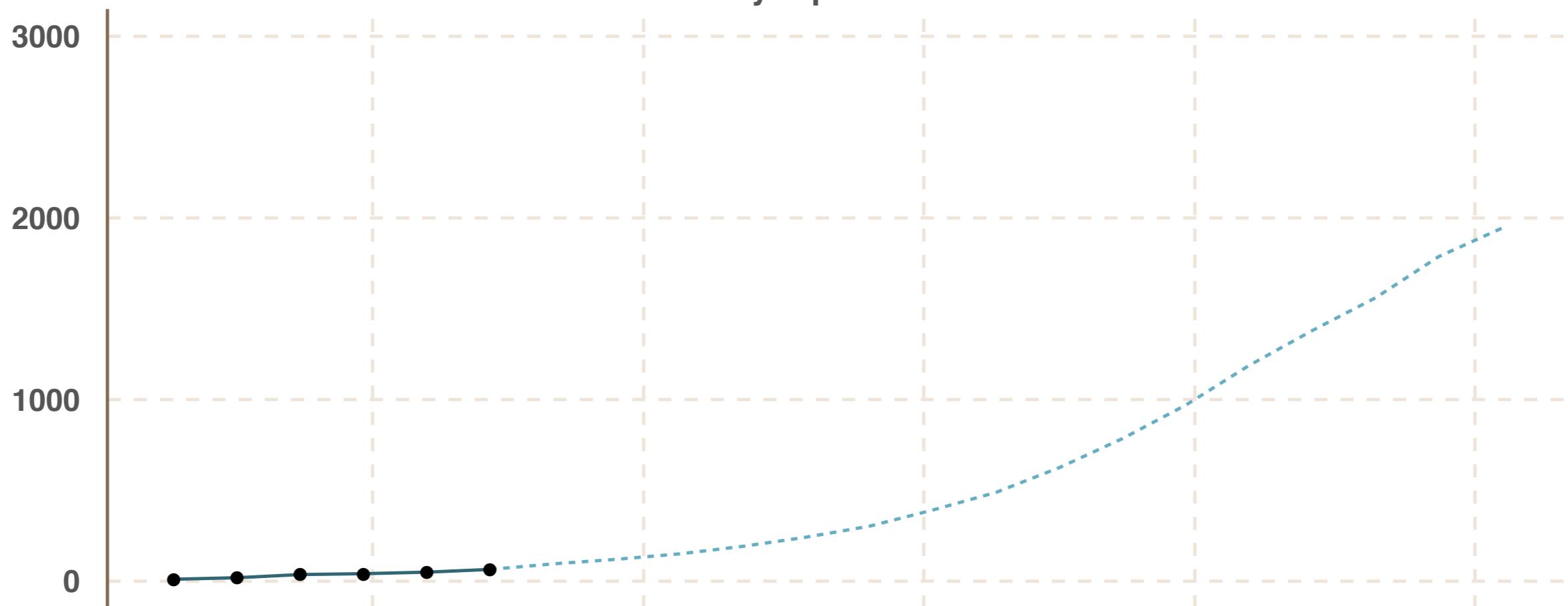
## Weekly reported cases



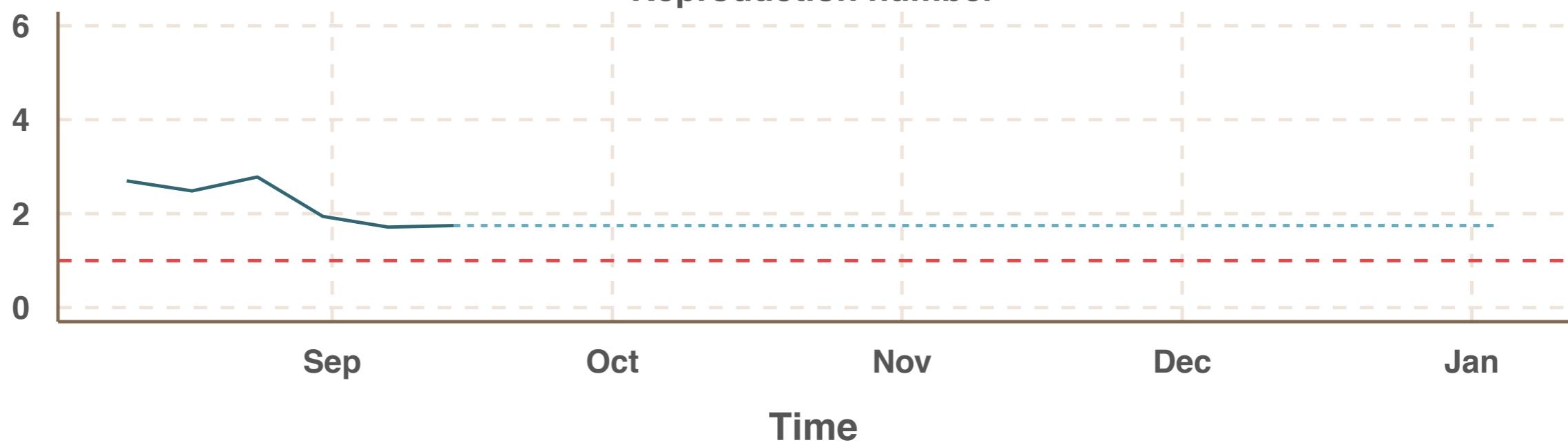
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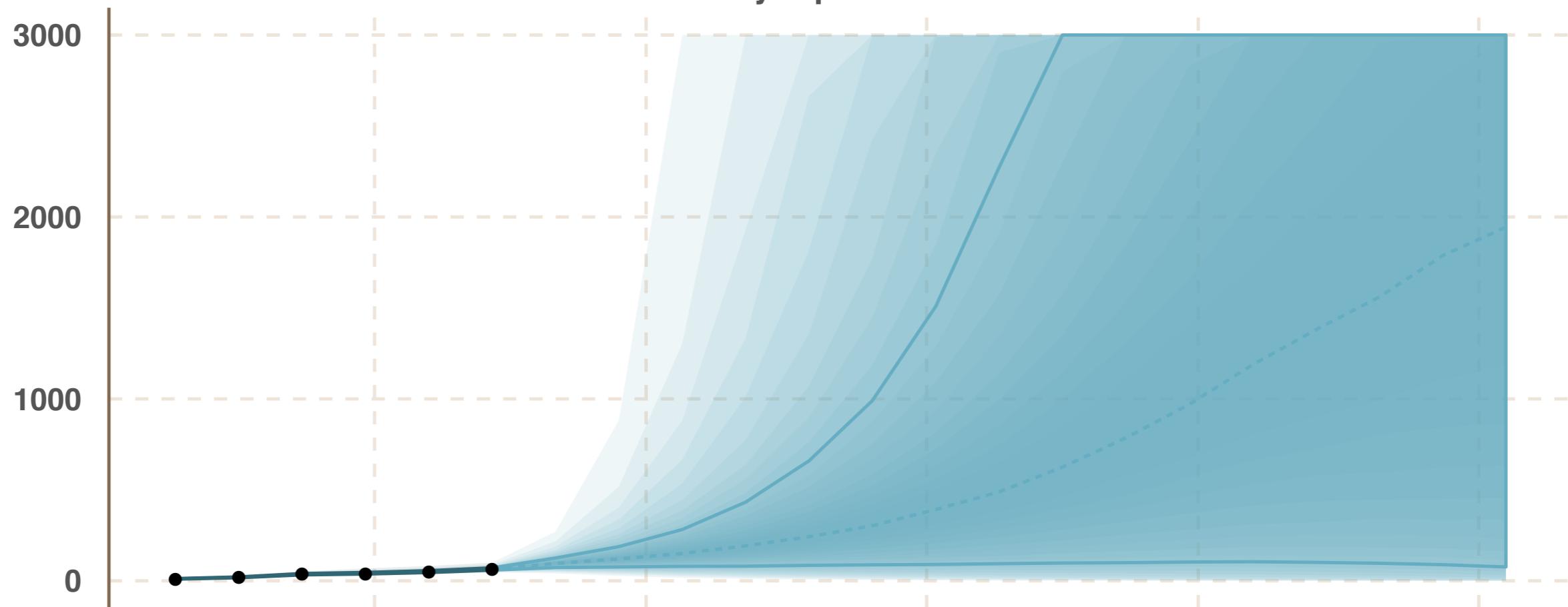
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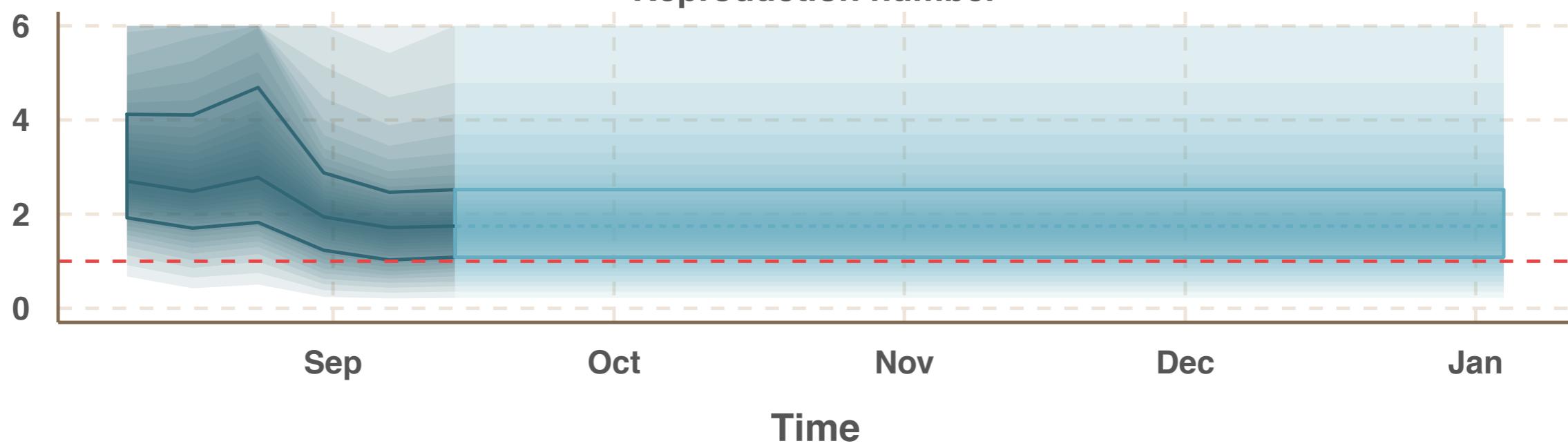
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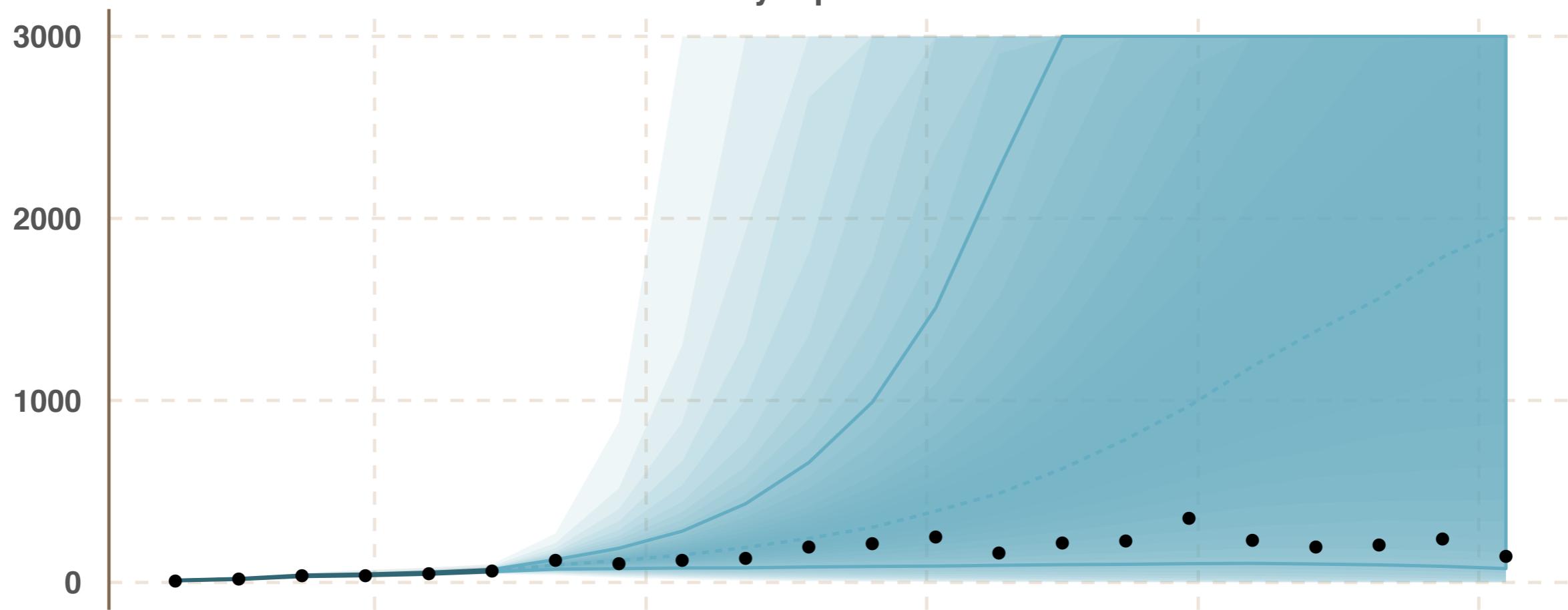
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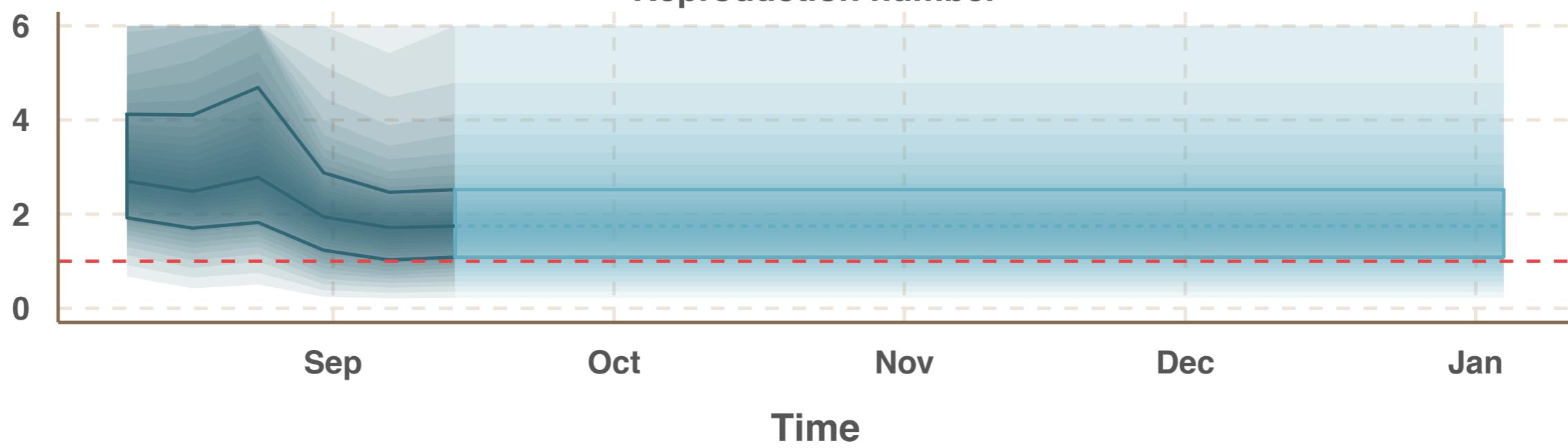
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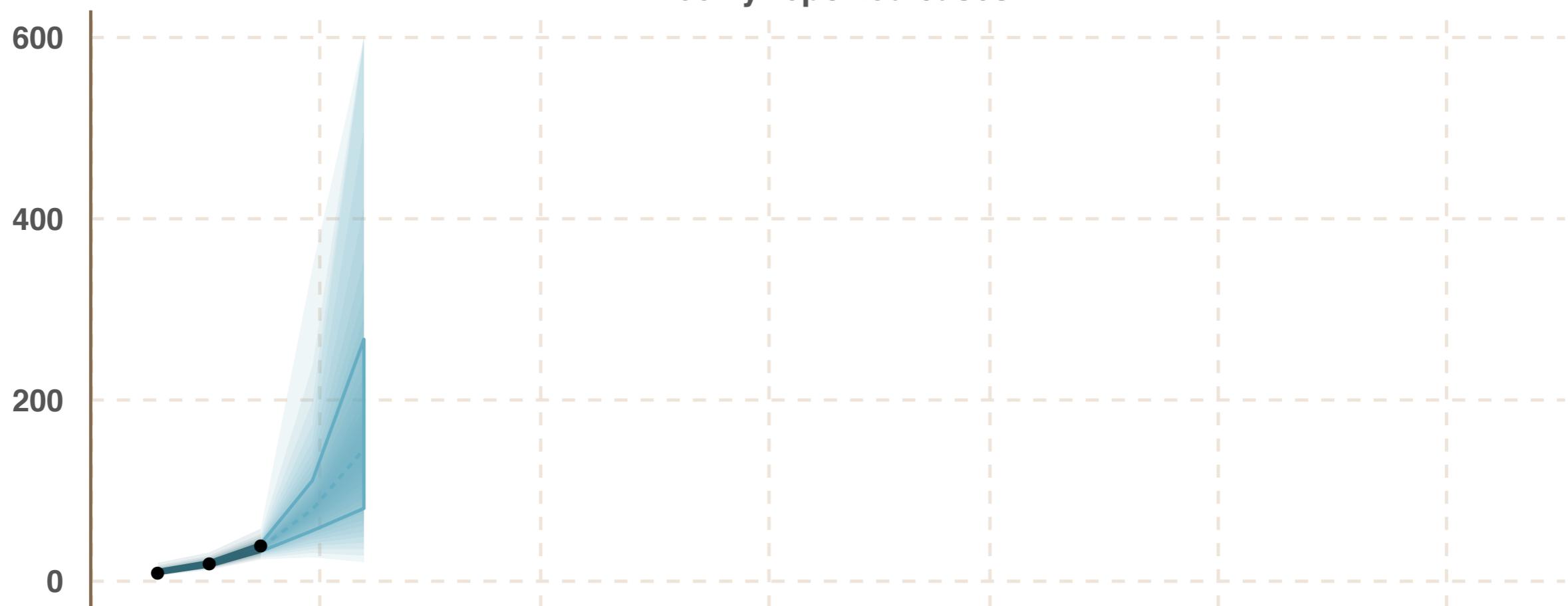
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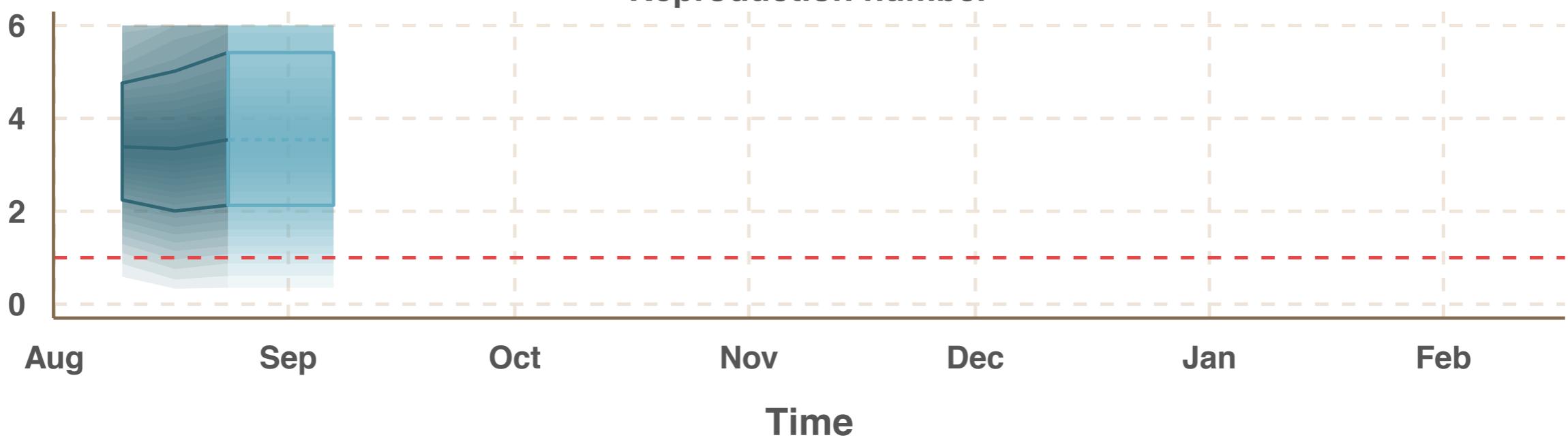
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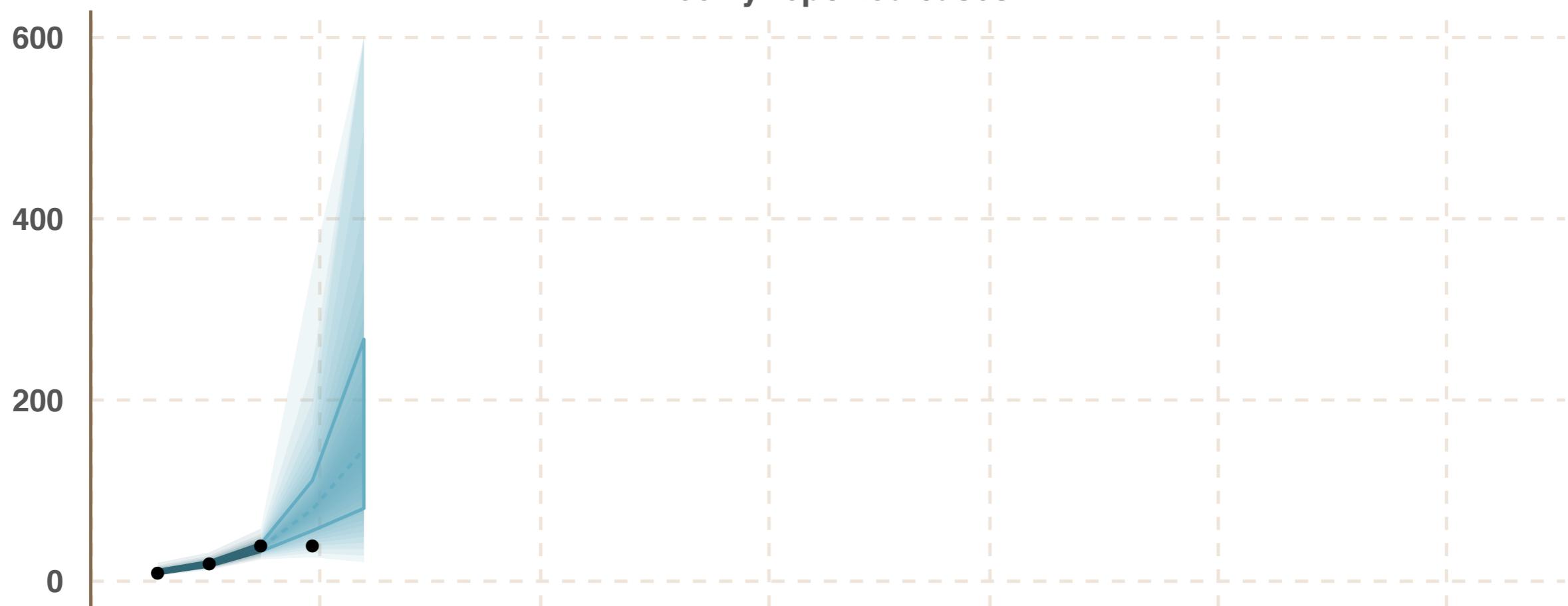
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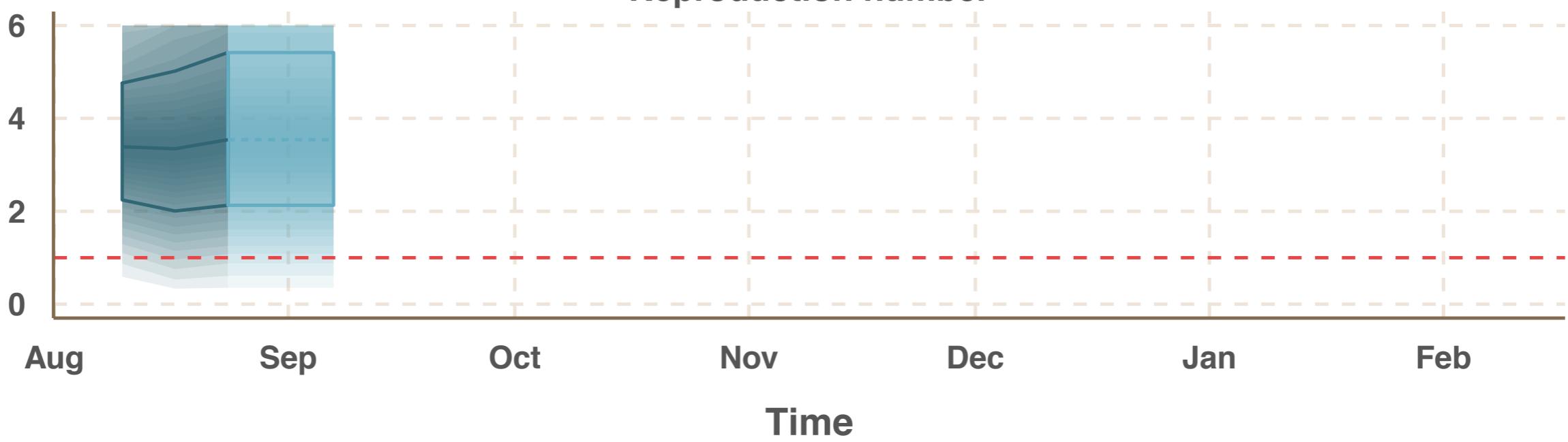
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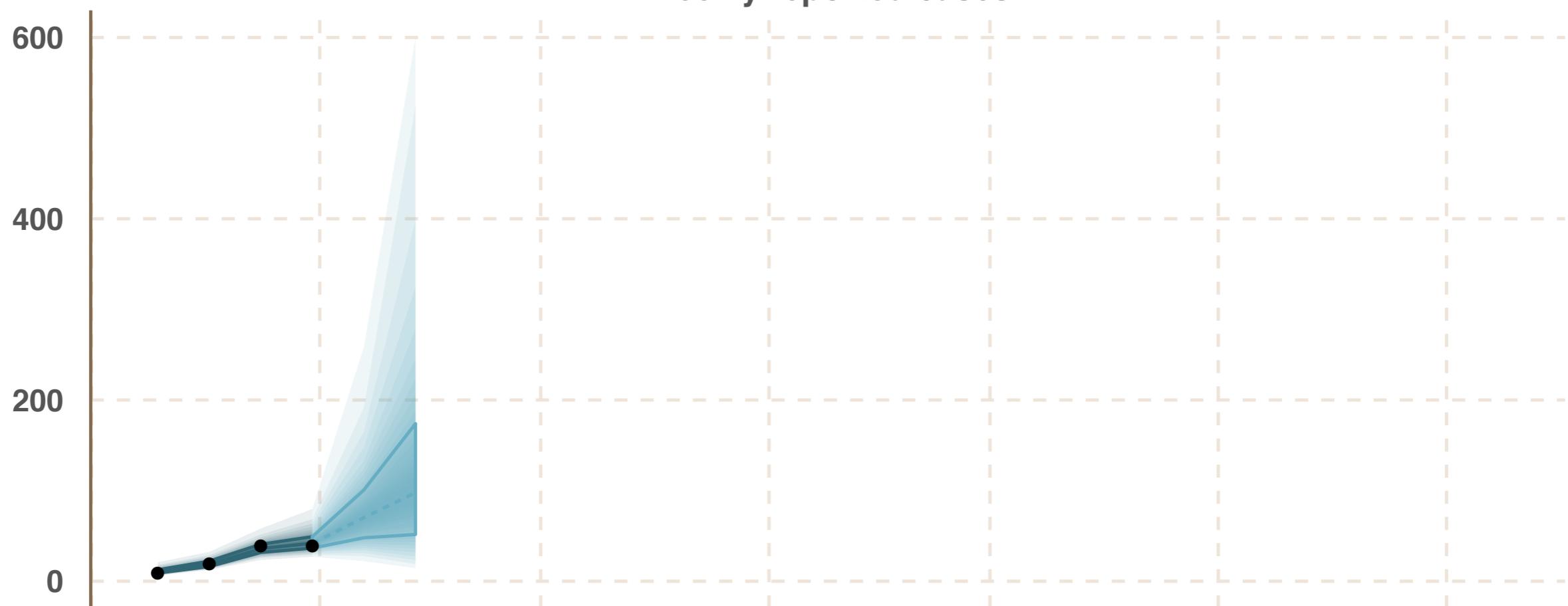
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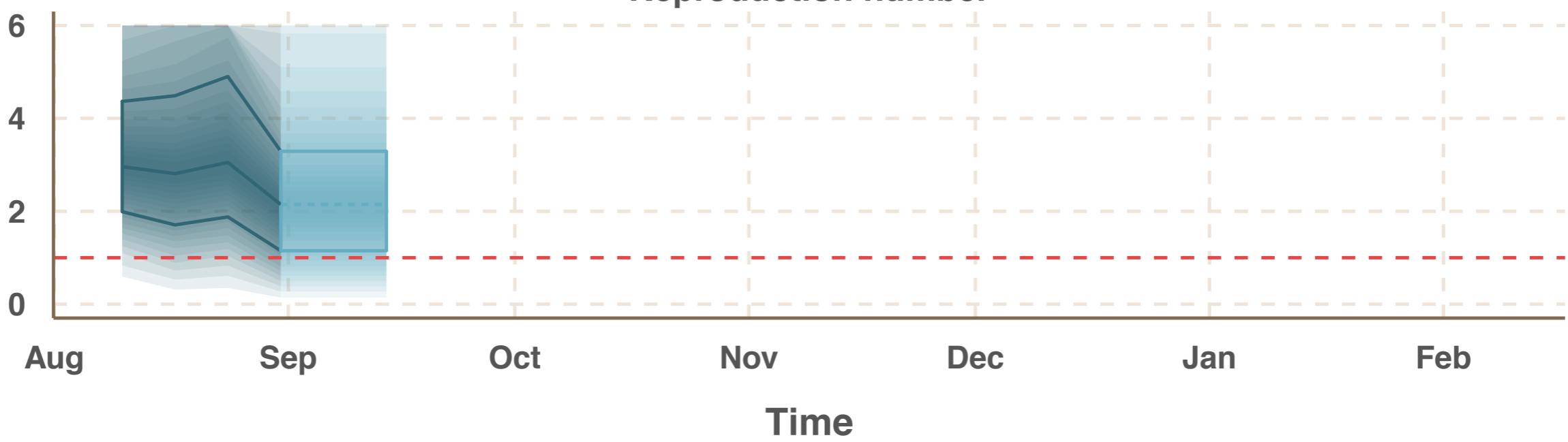
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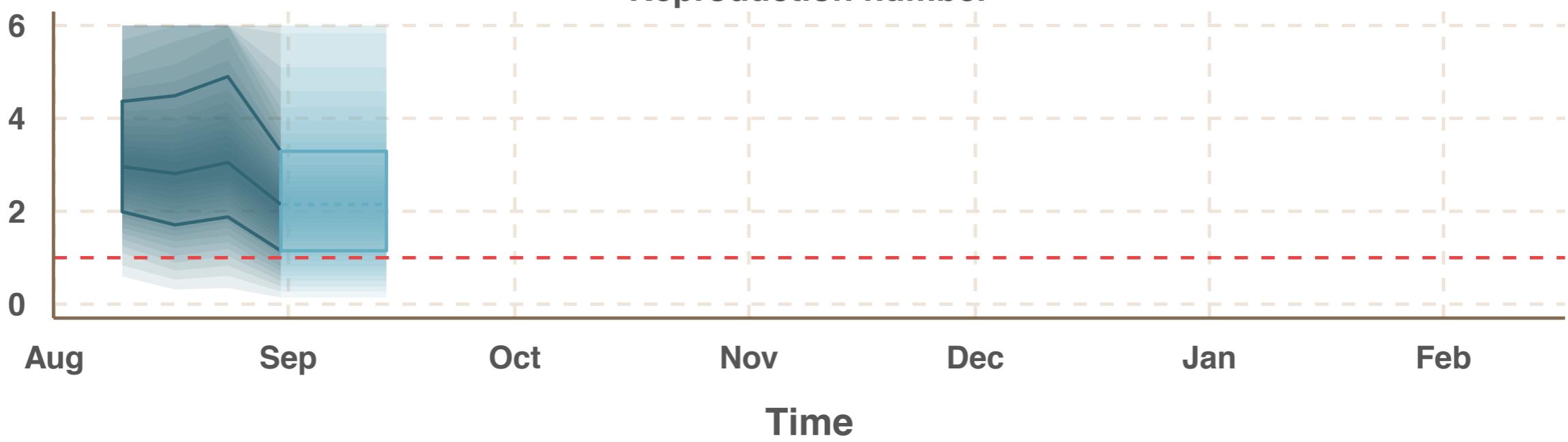
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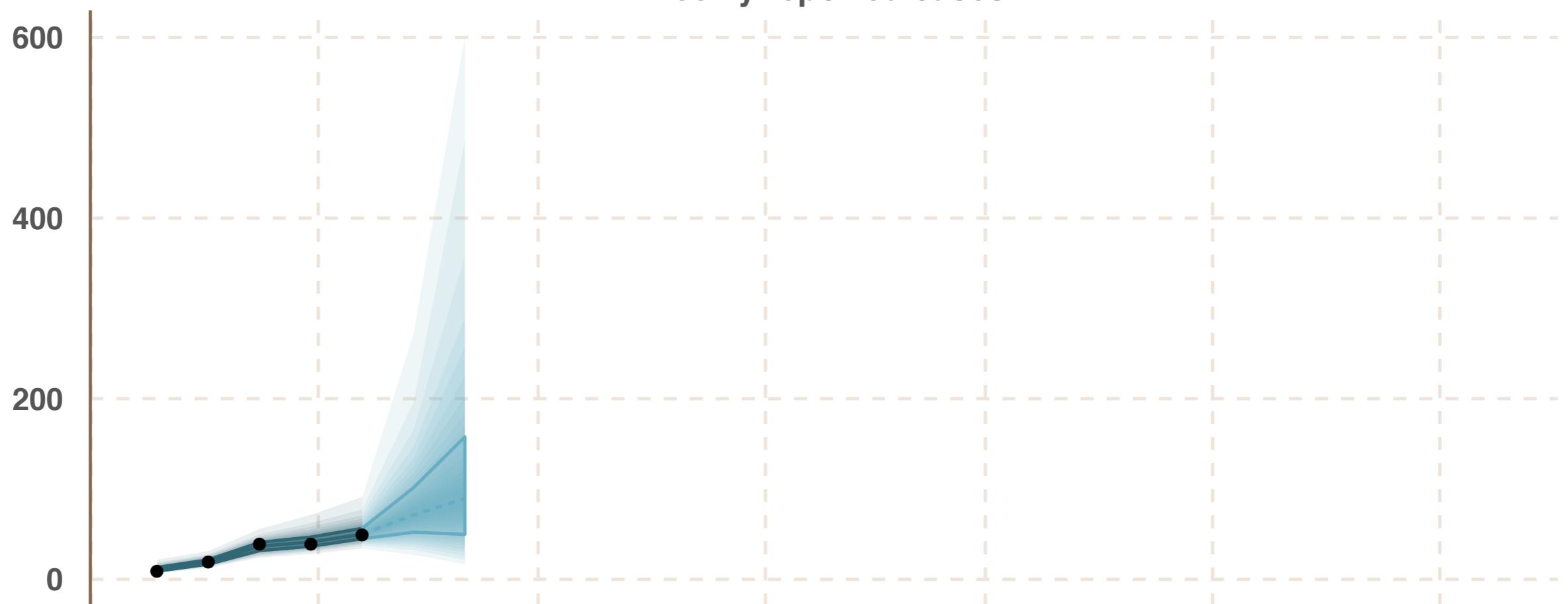
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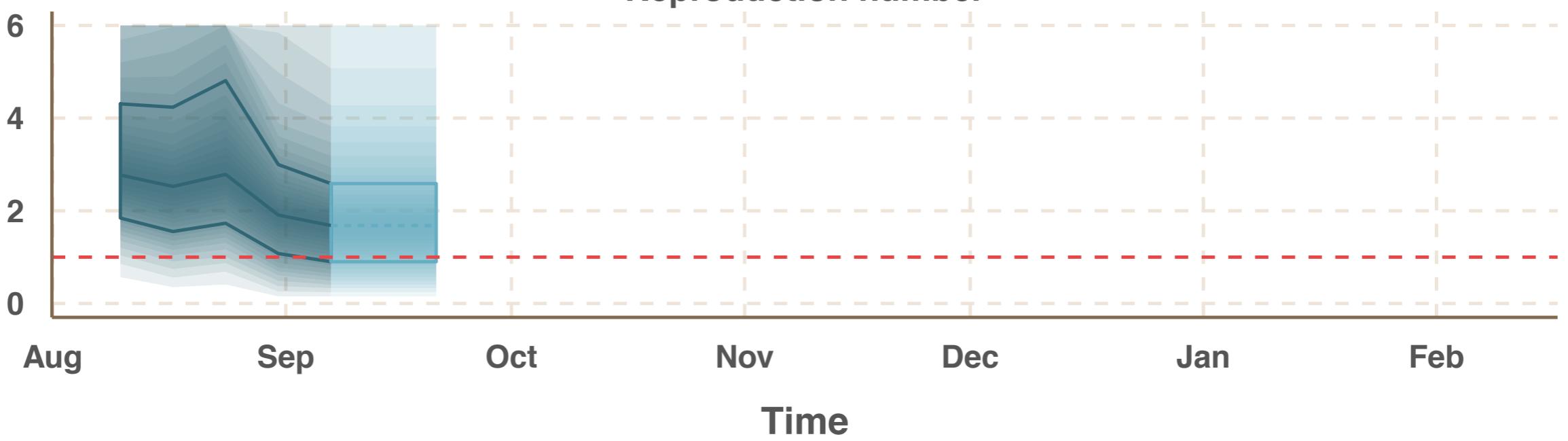
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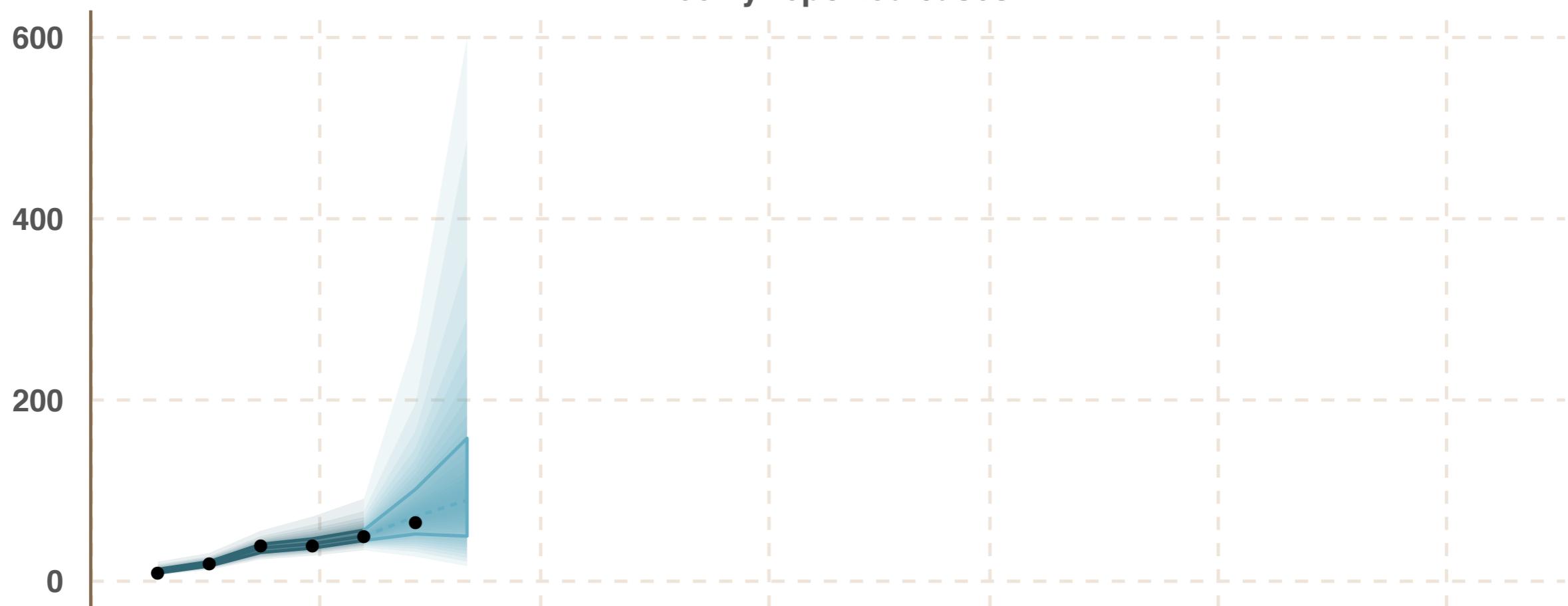
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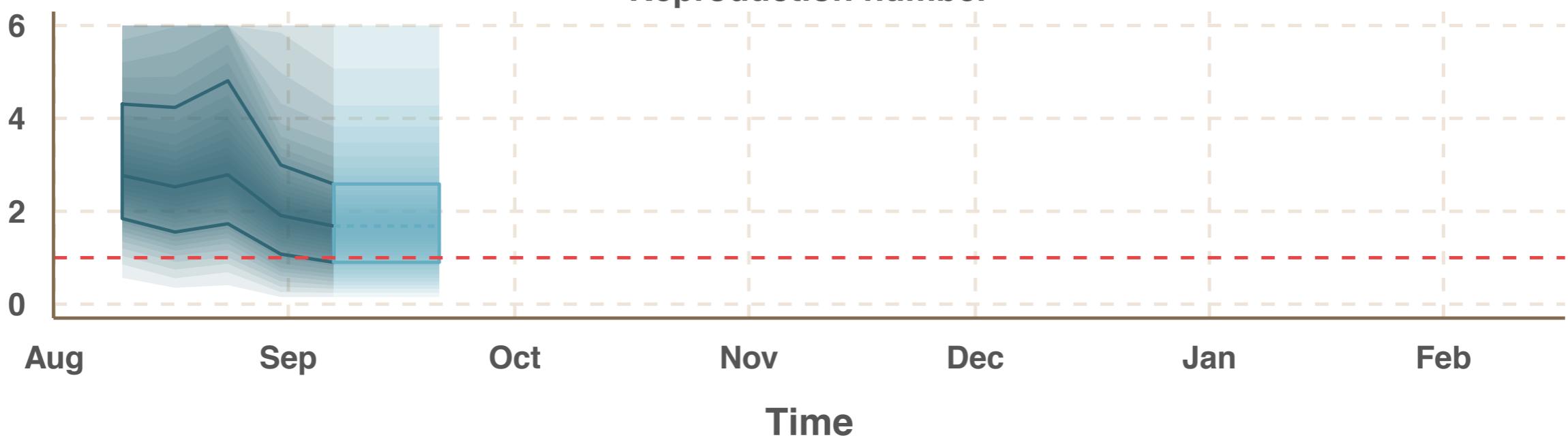
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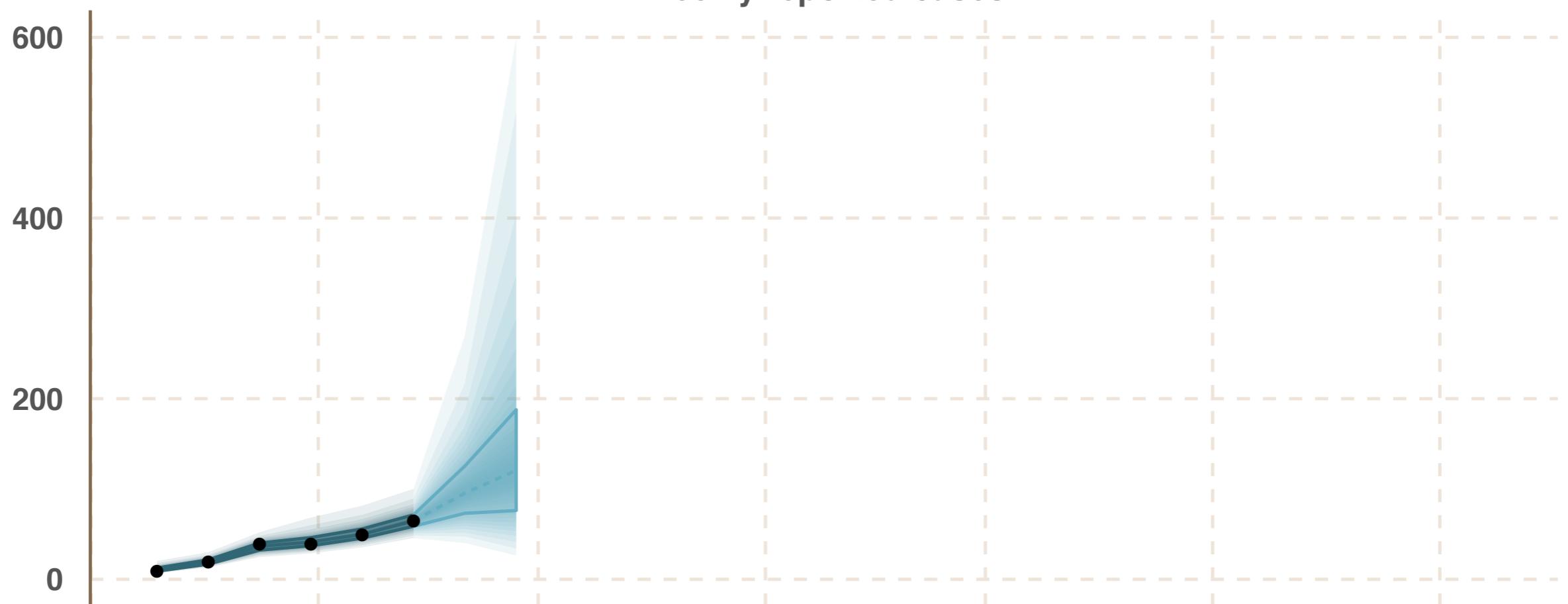
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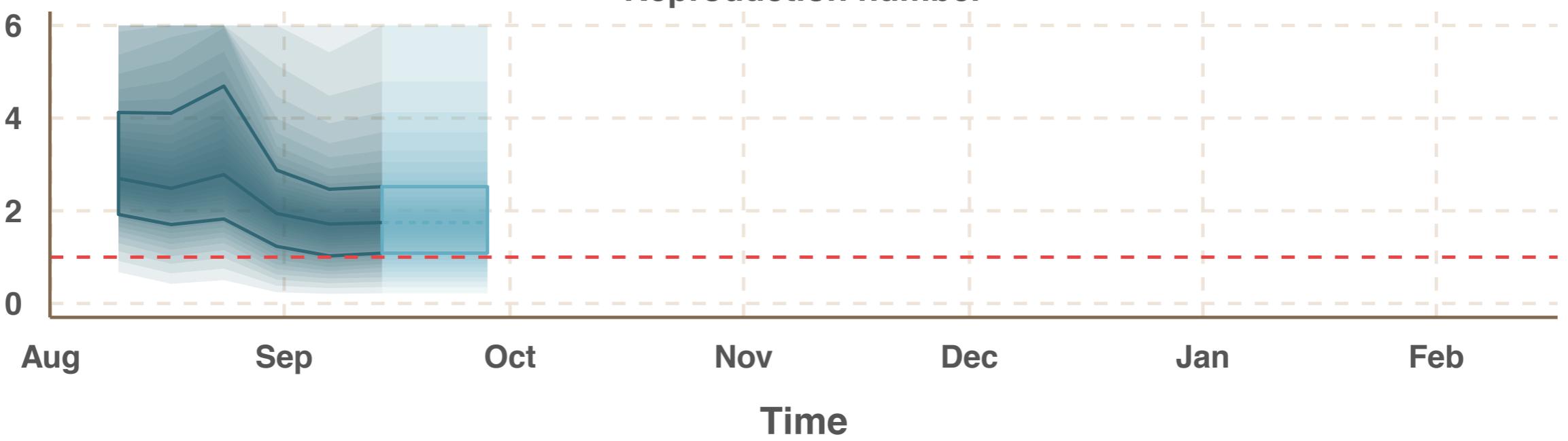
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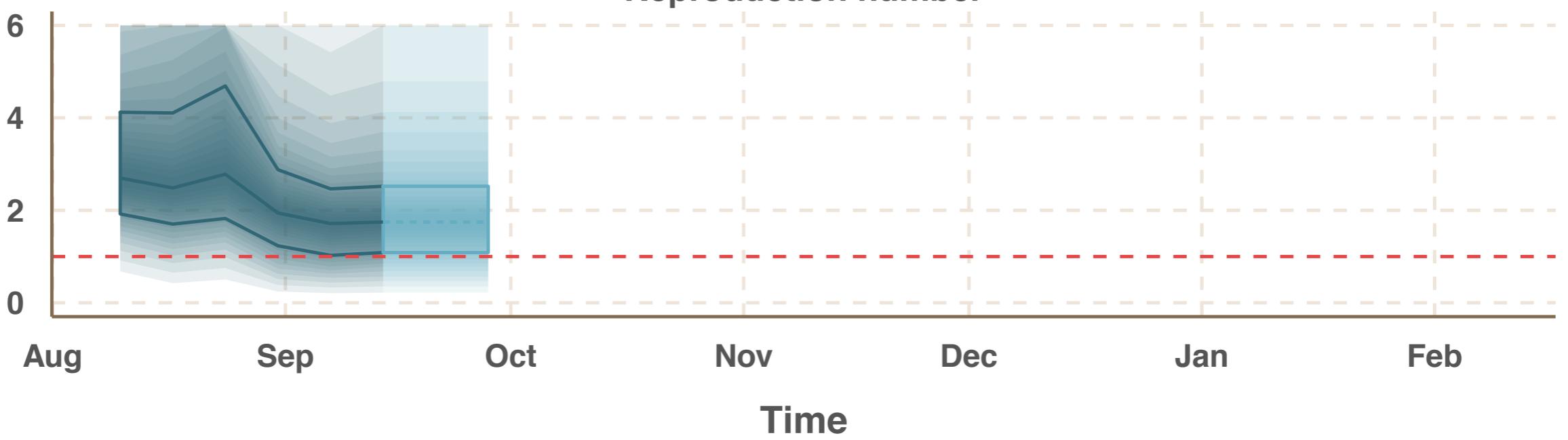
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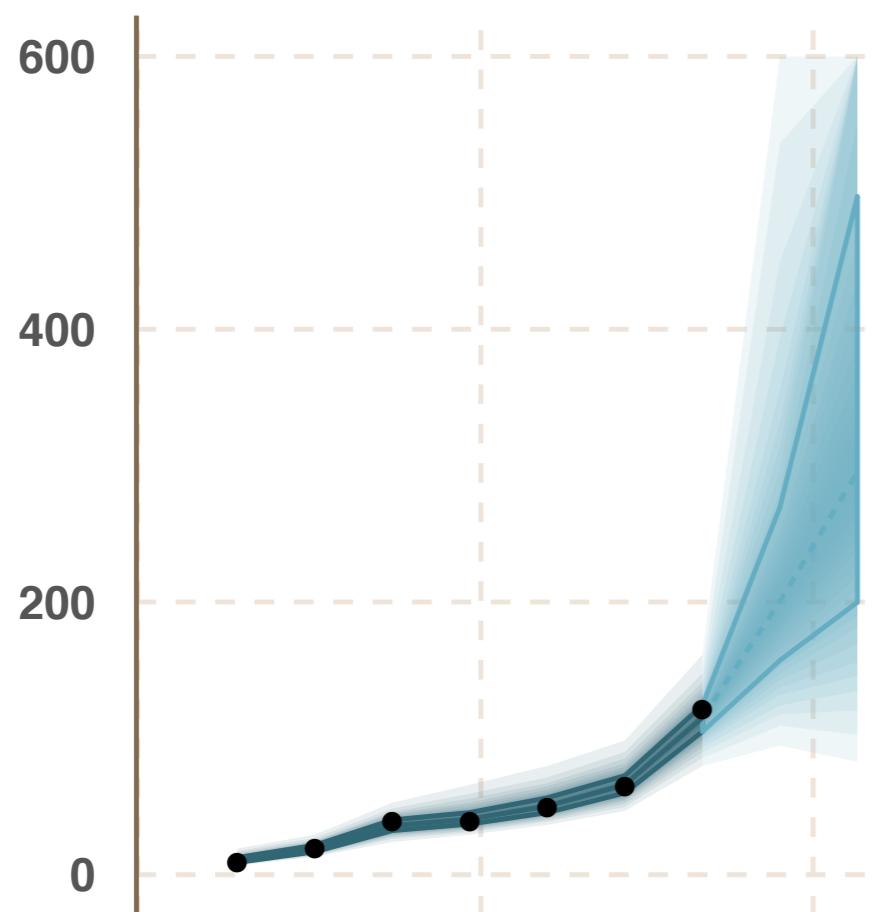
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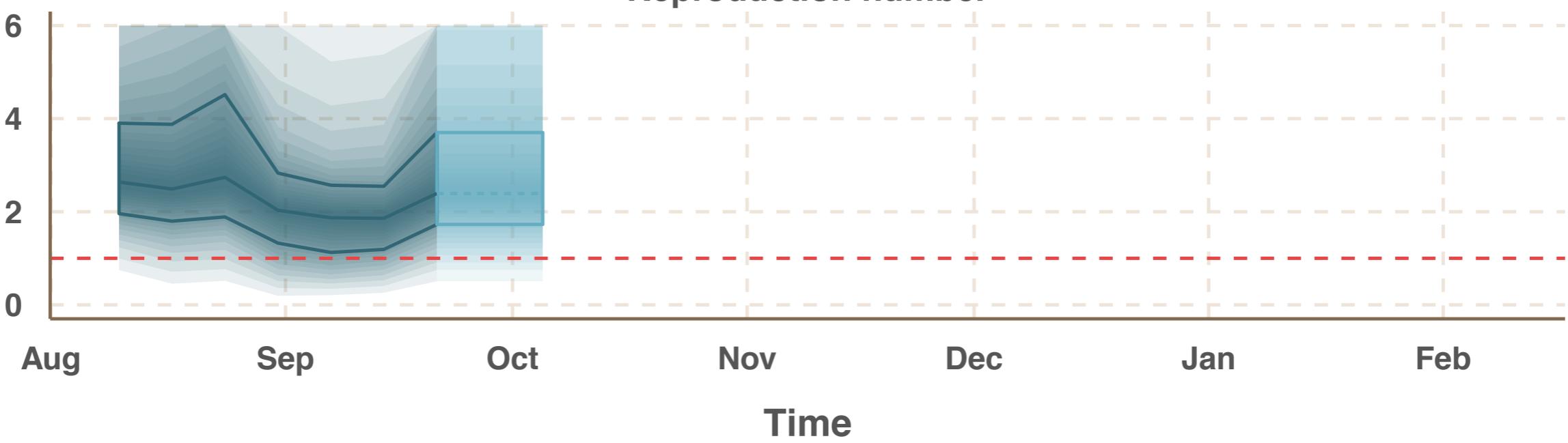
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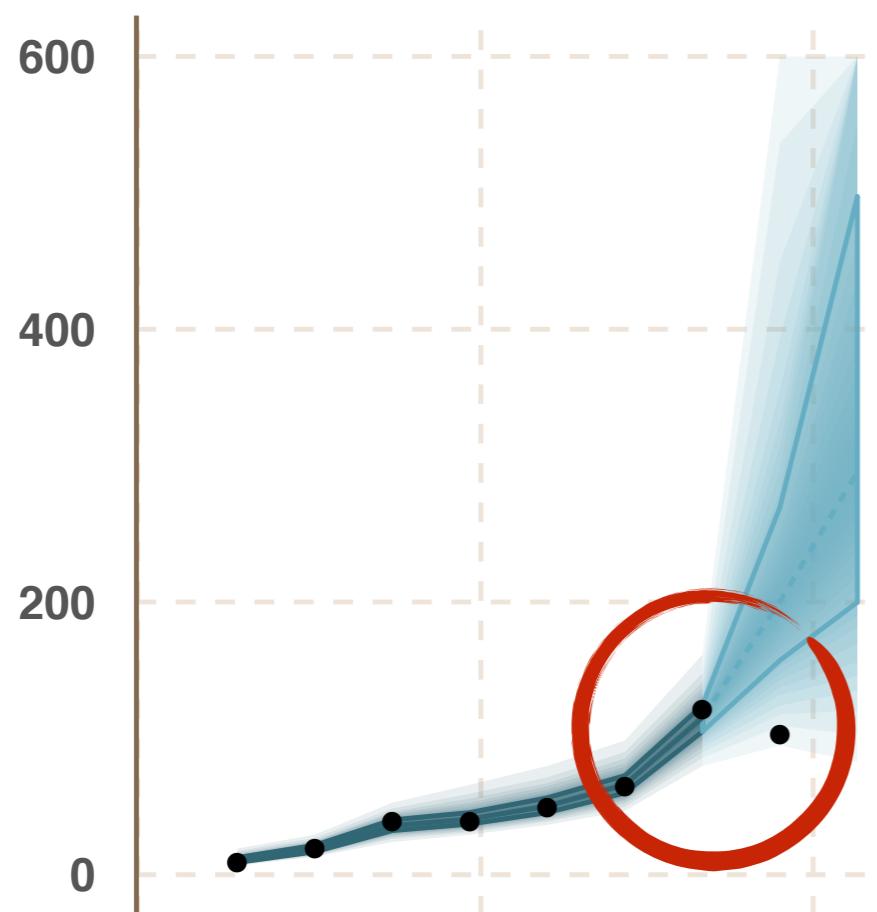
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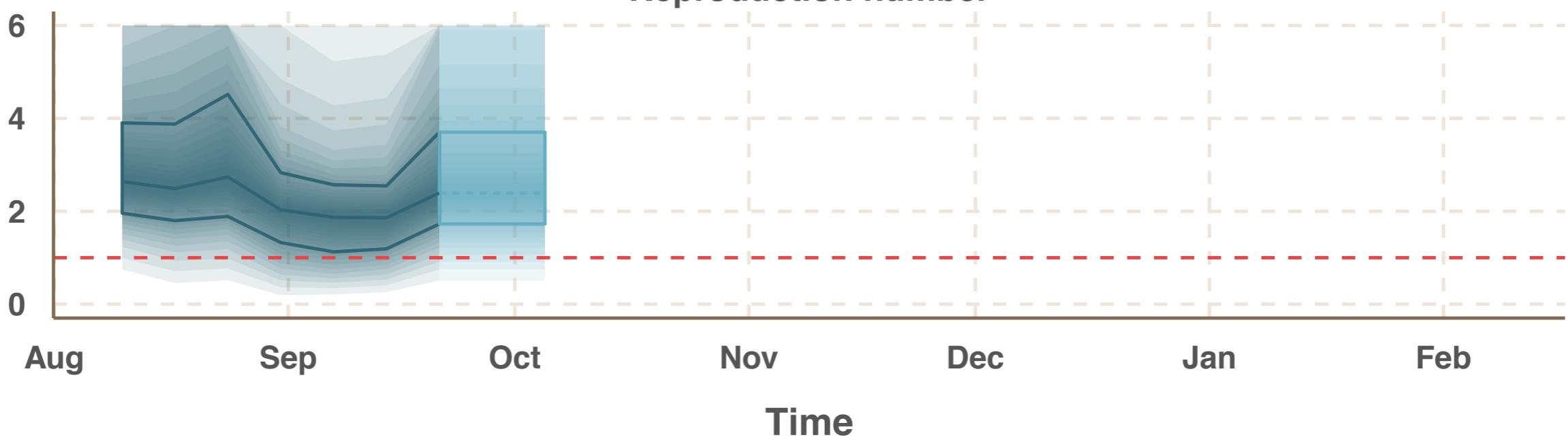


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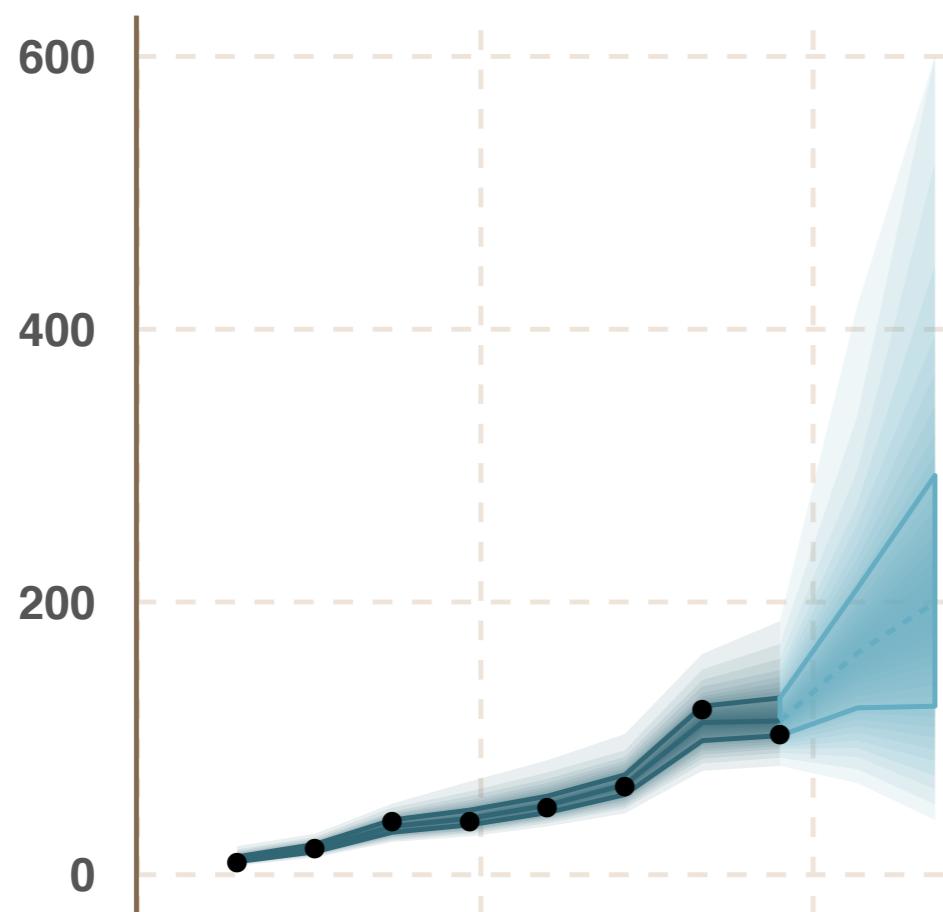


3 day shut down  
mid September

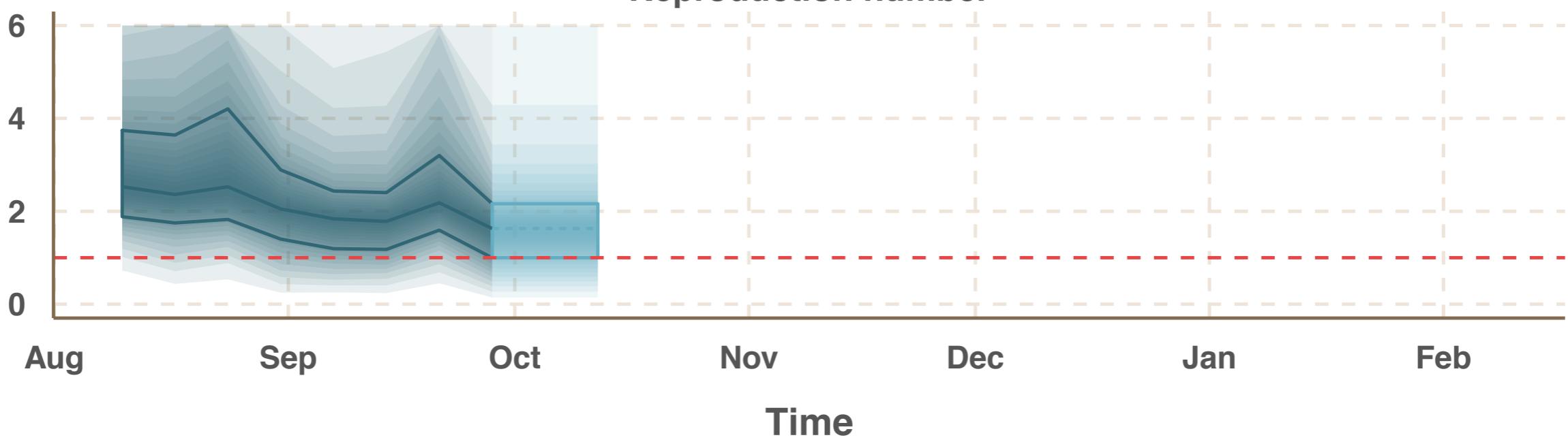
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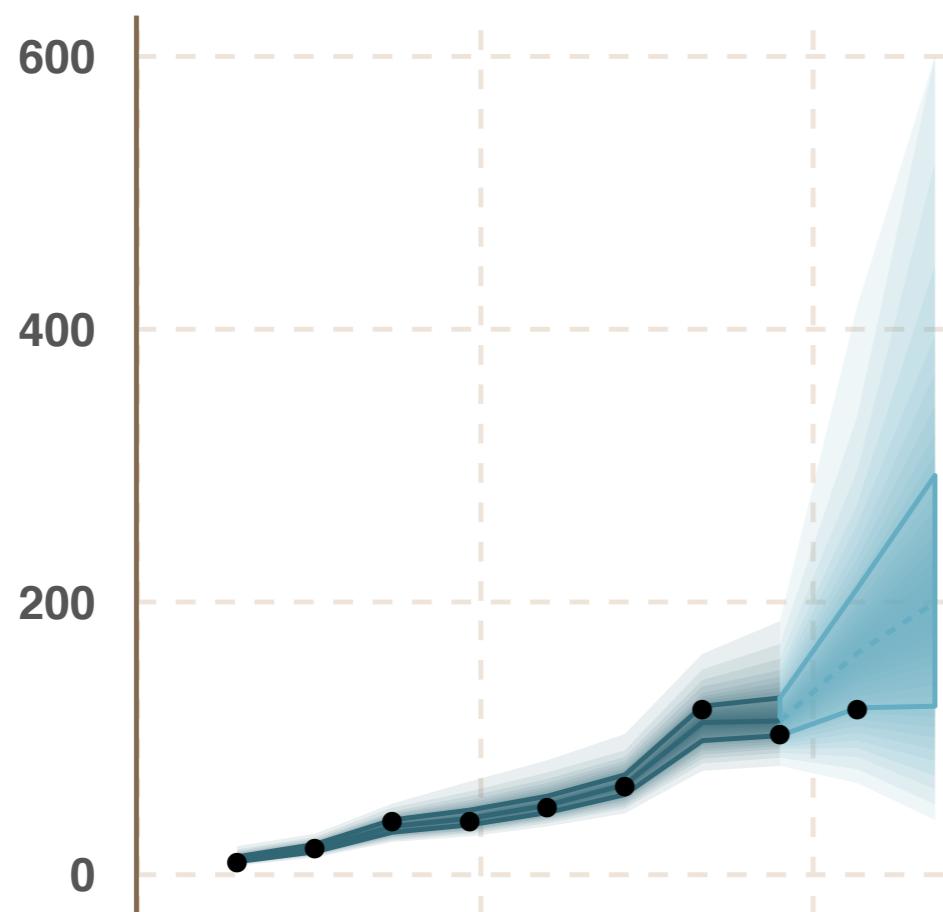
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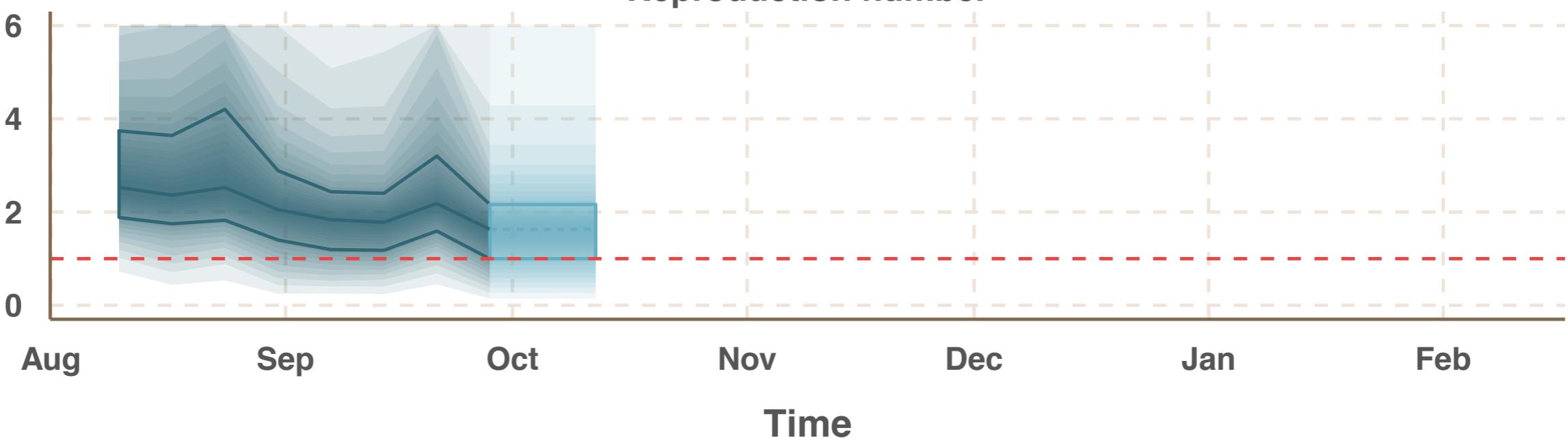
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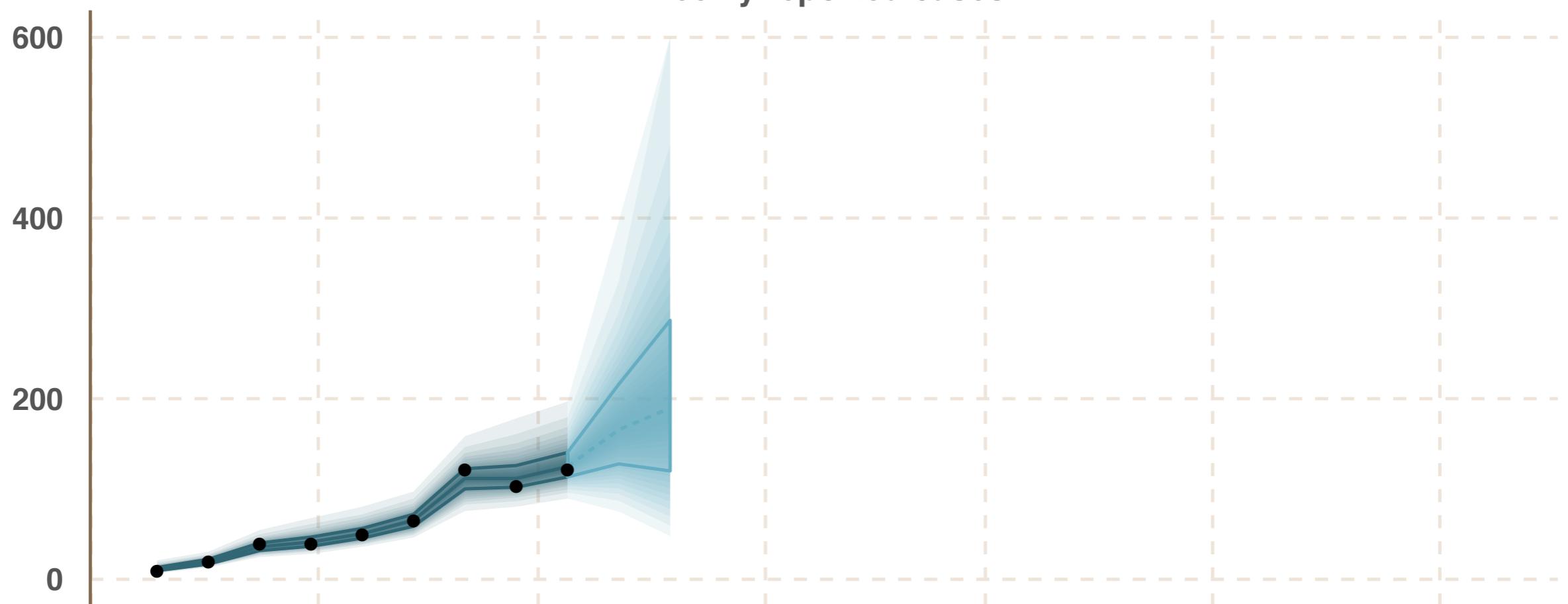
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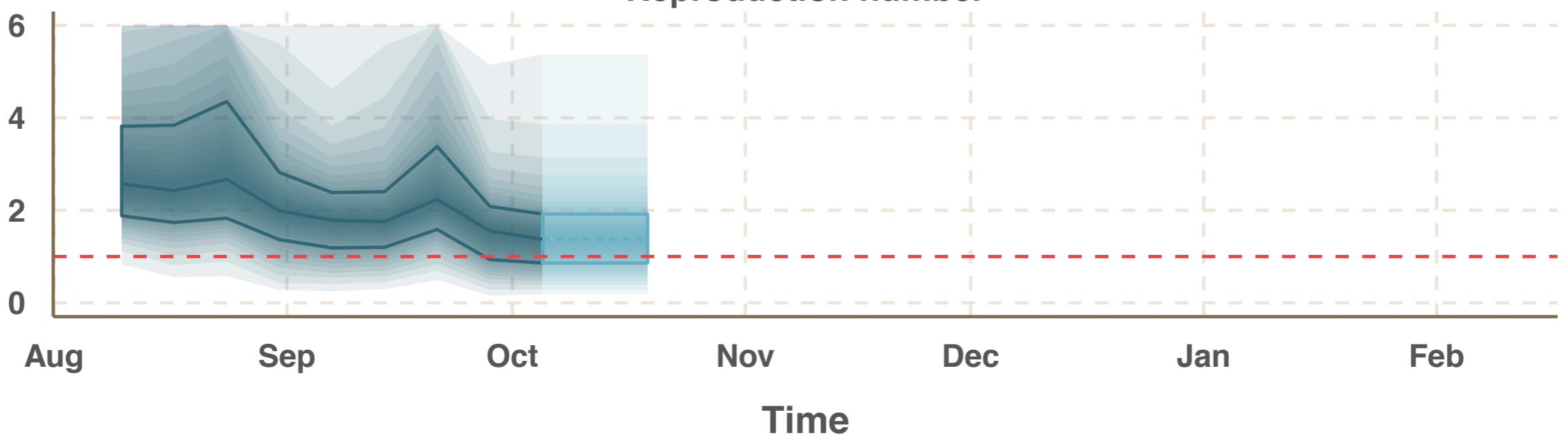
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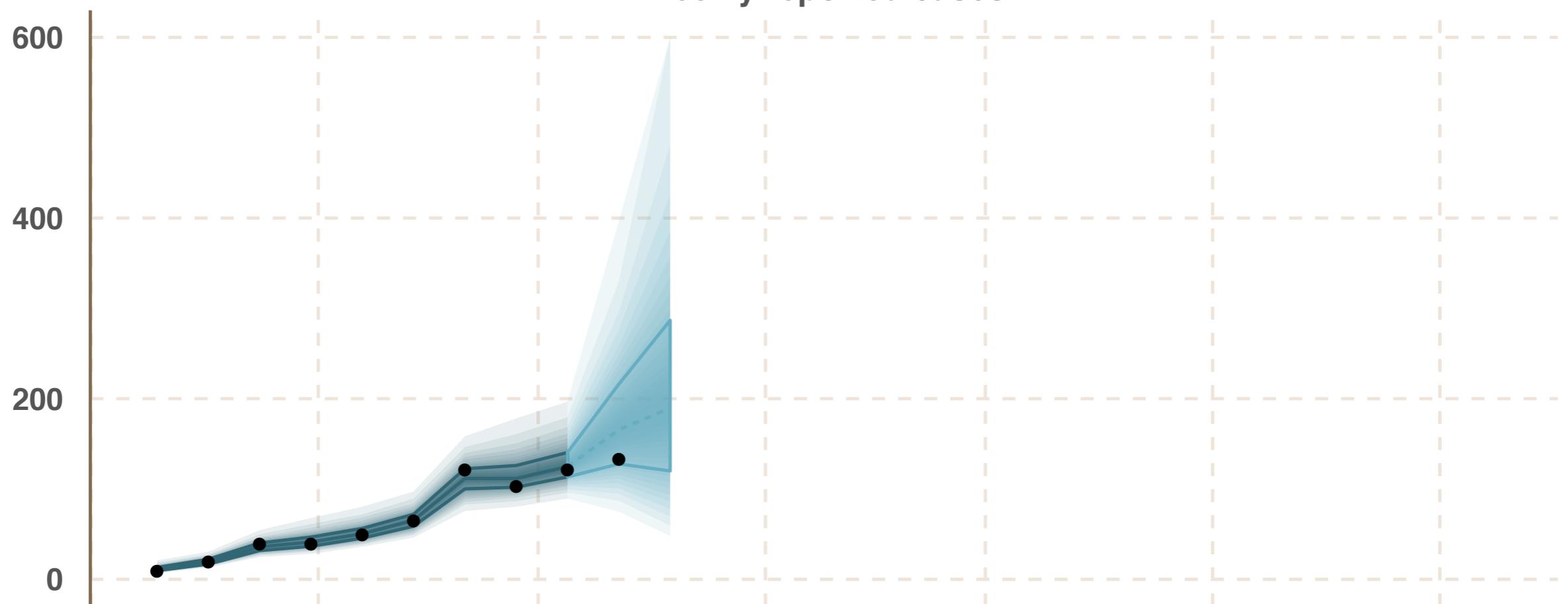
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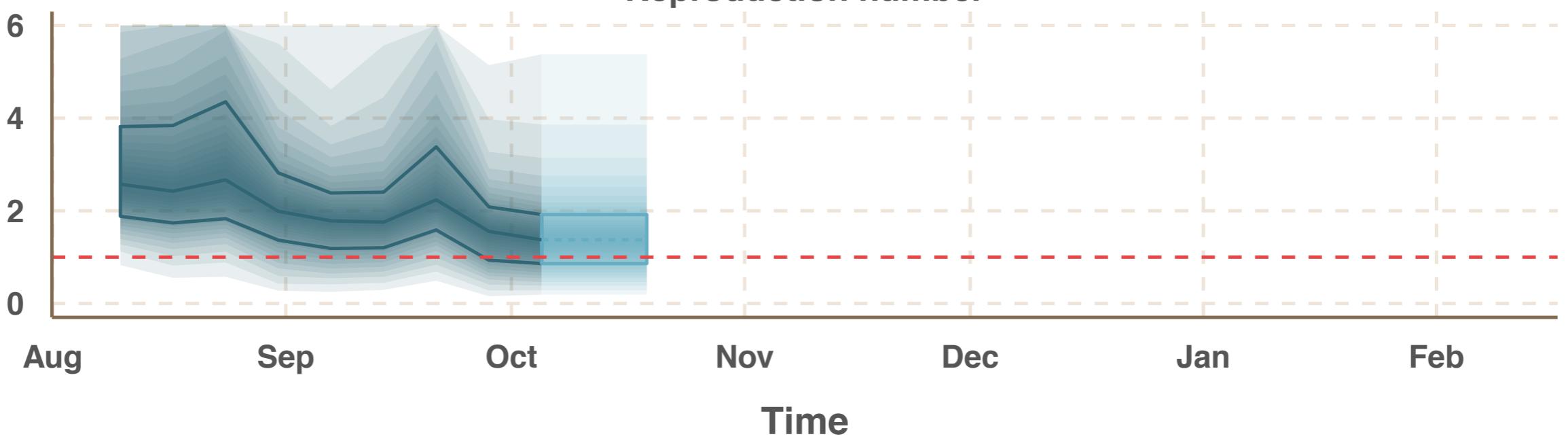
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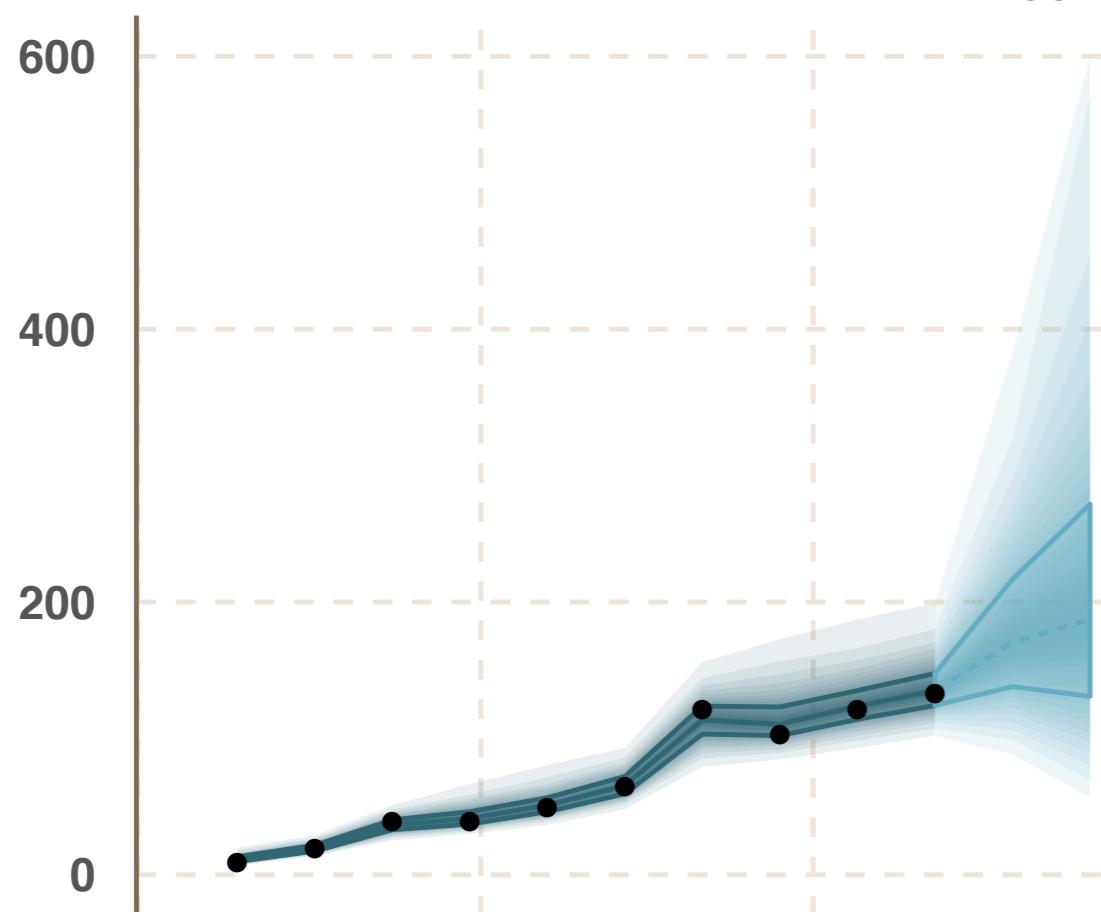
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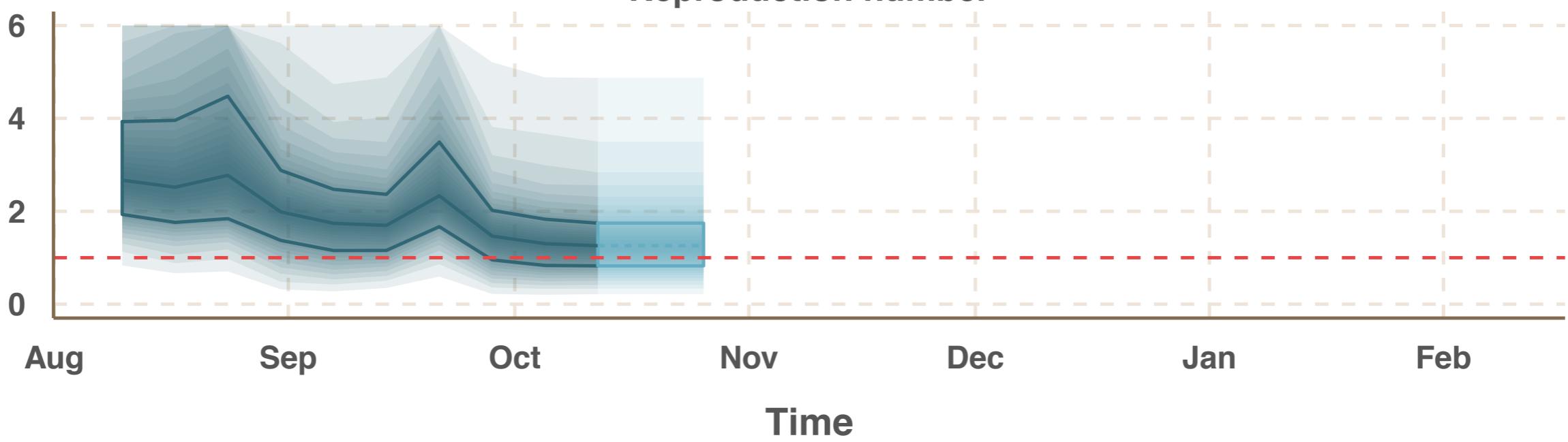
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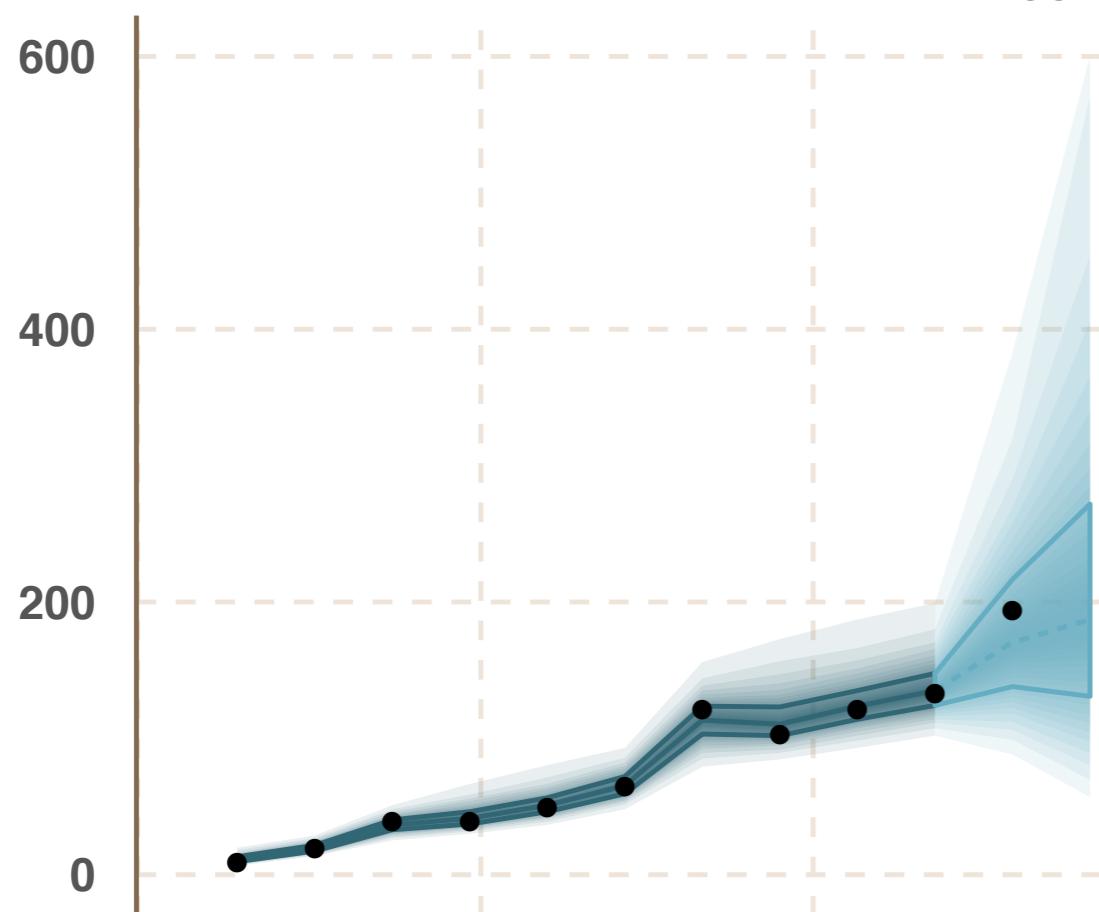
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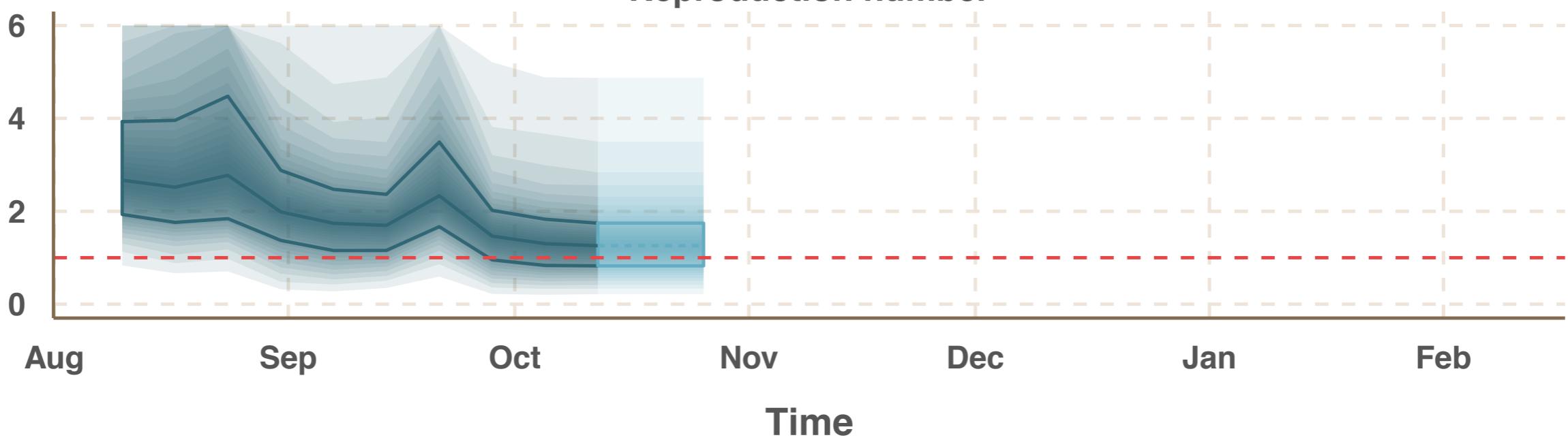
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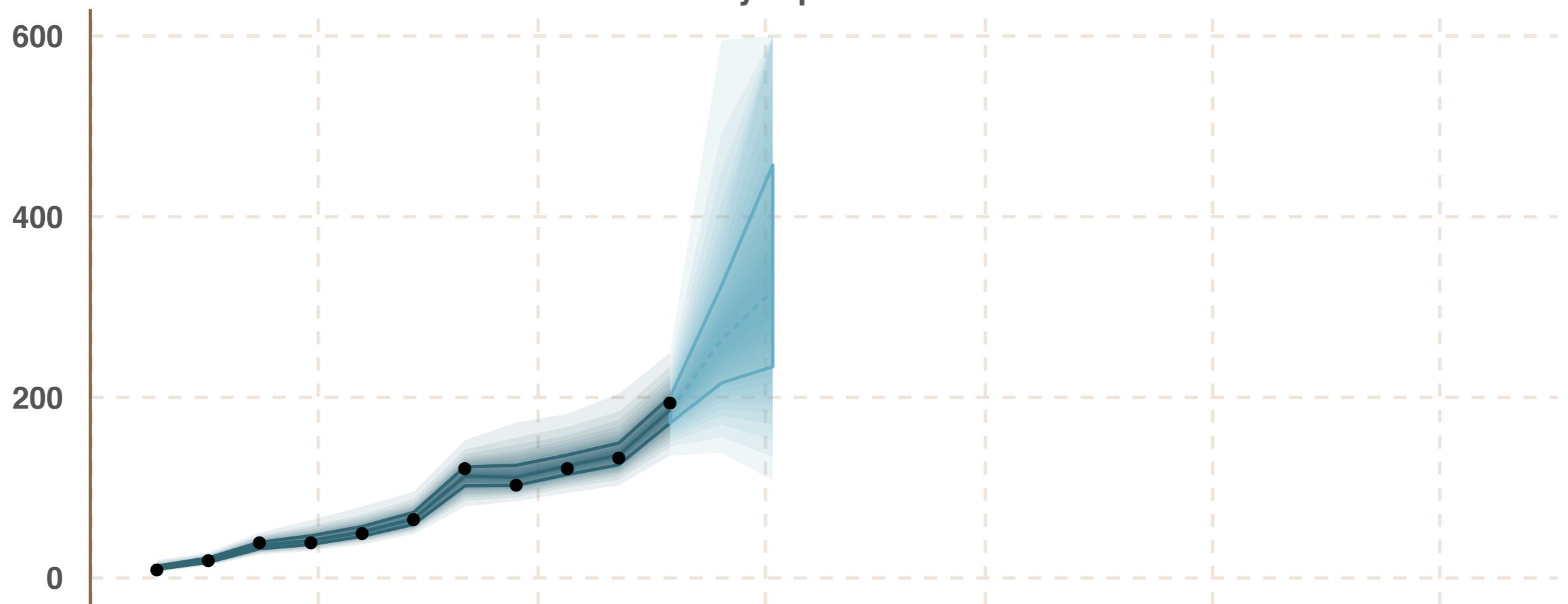
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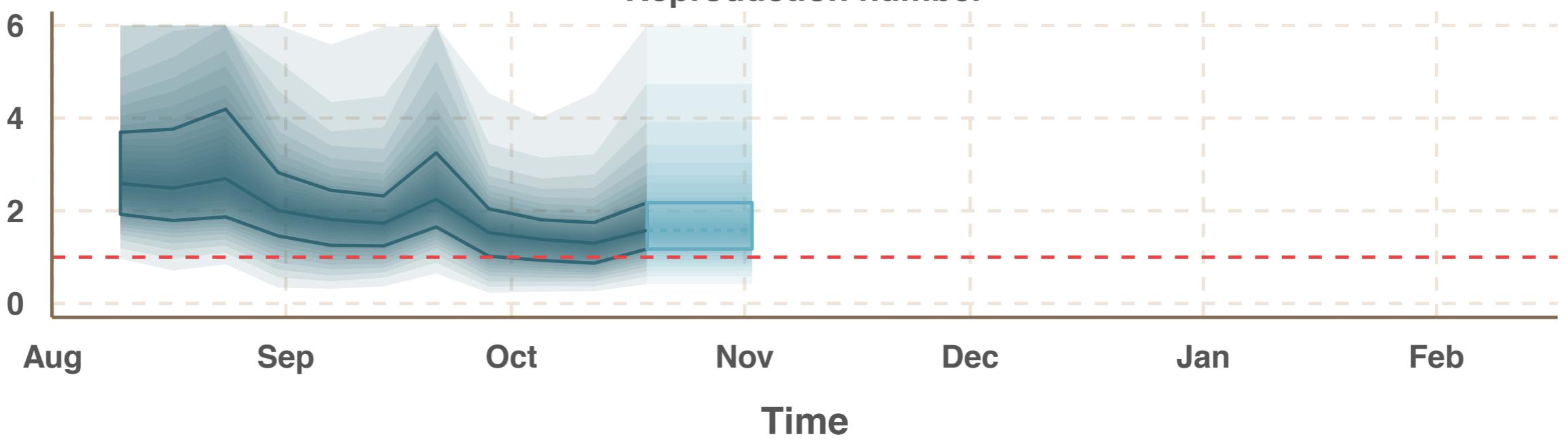
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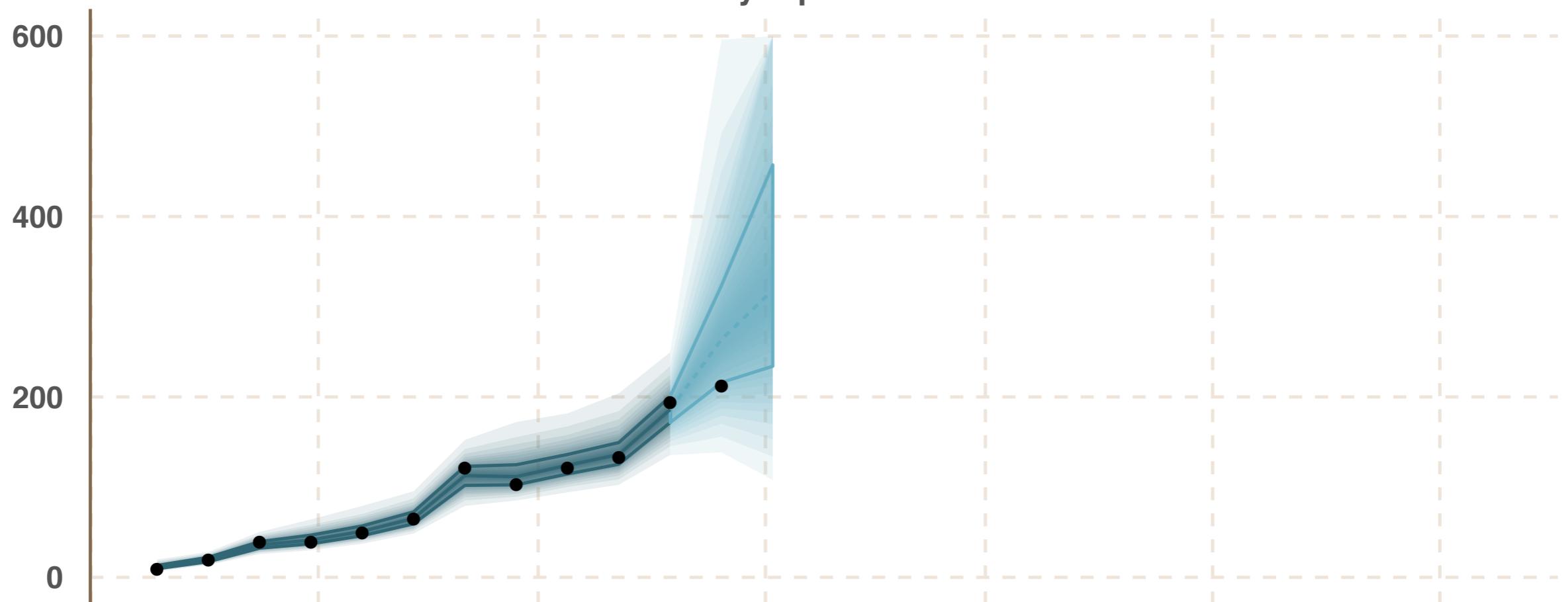
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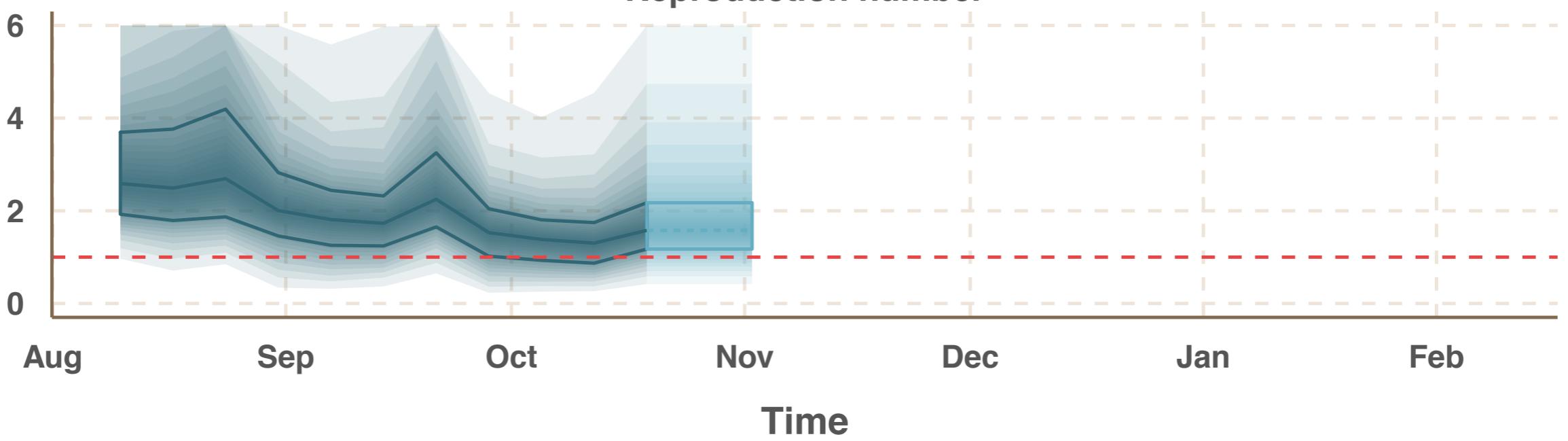
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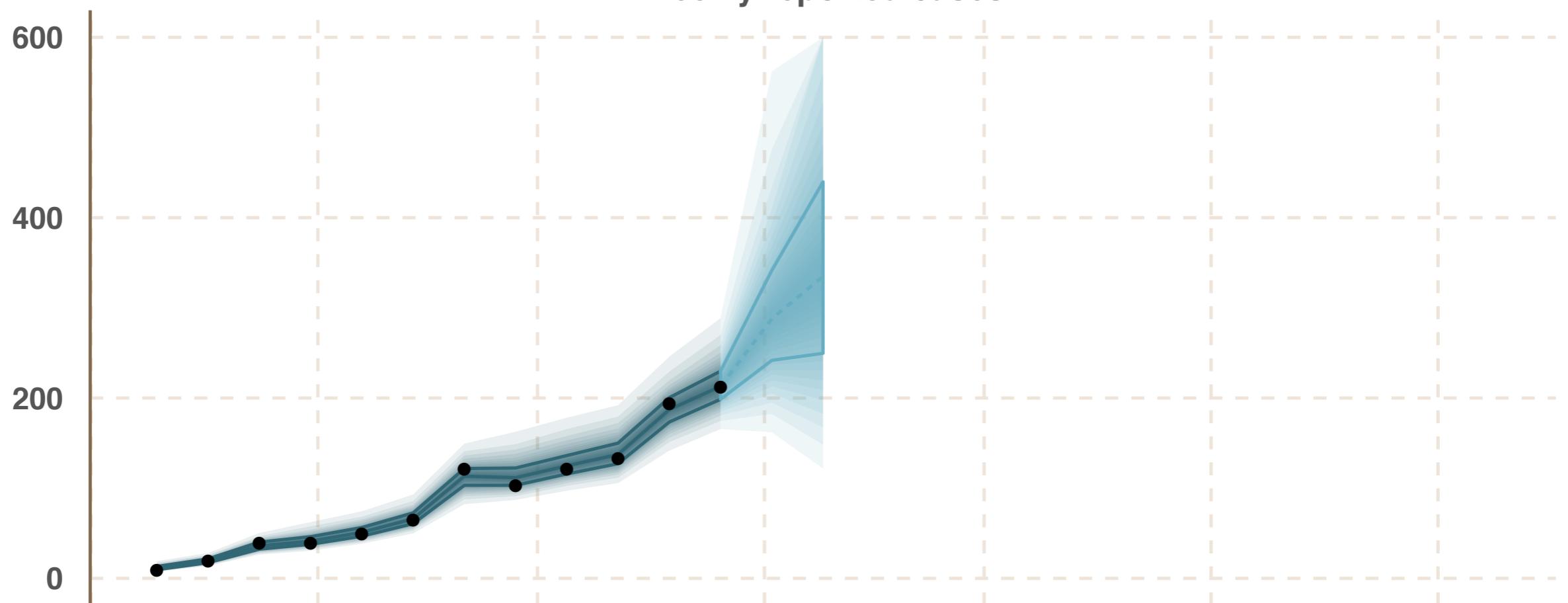
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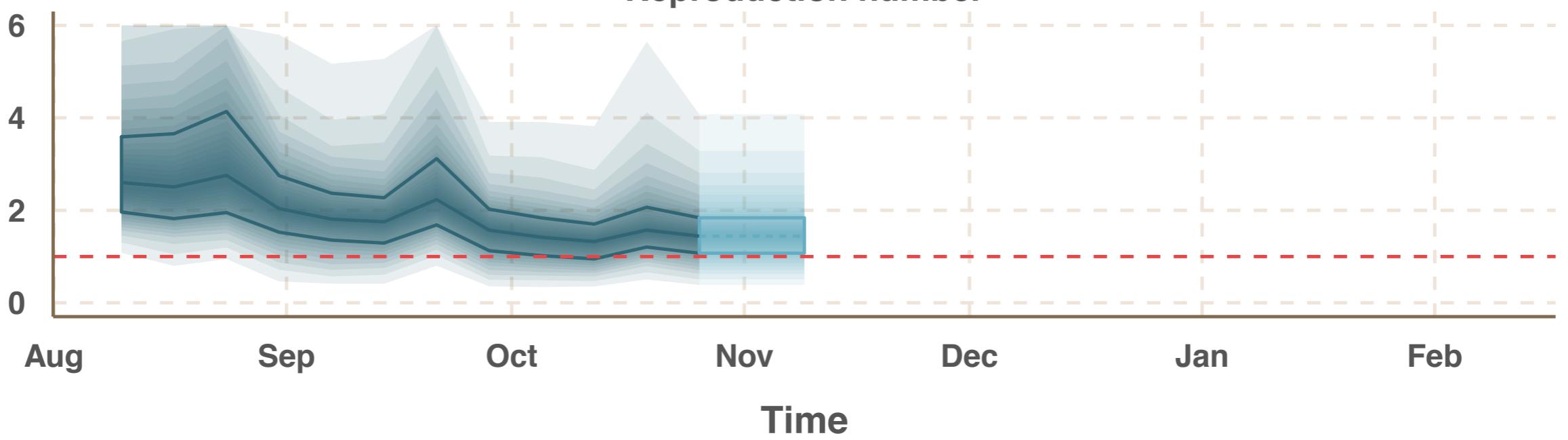
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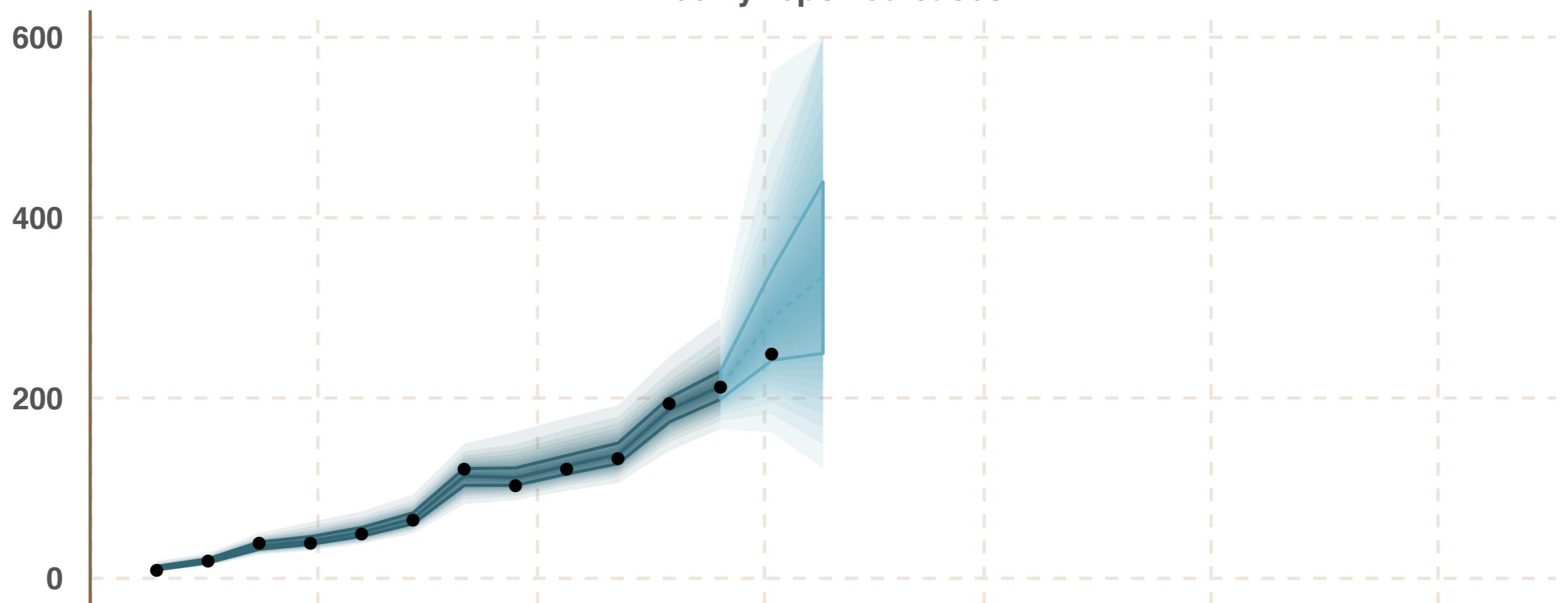
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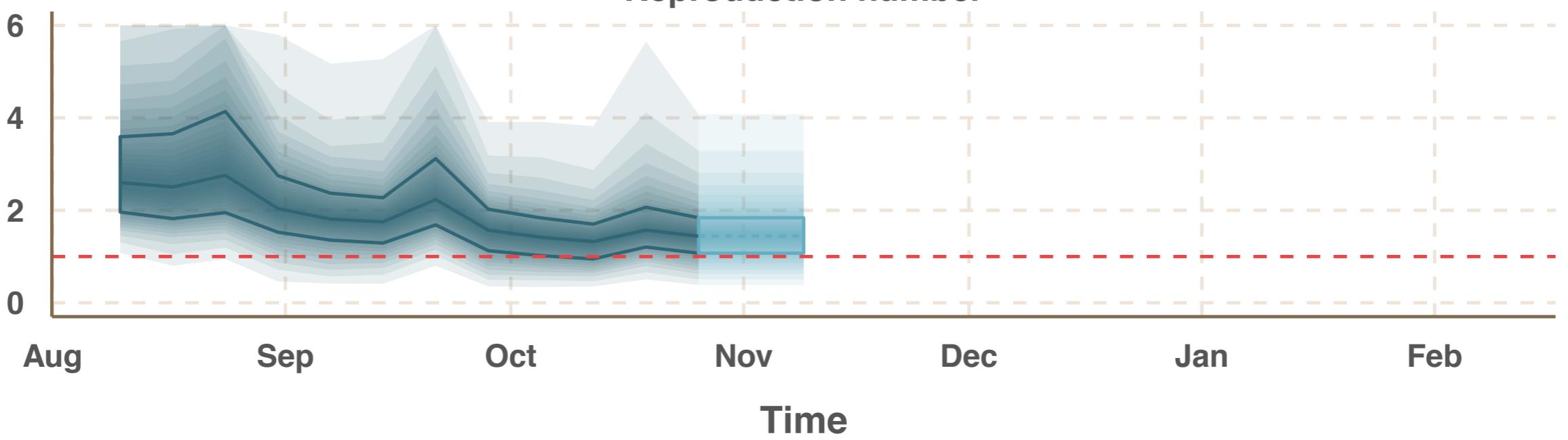
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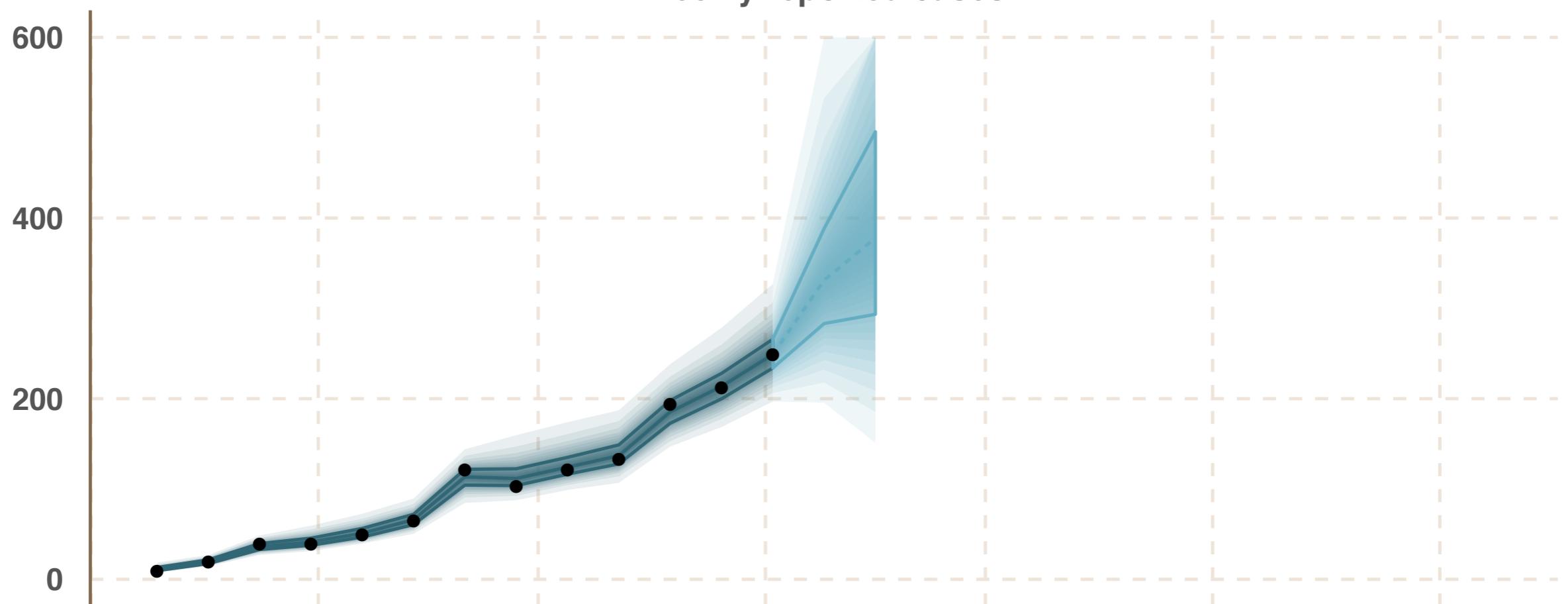
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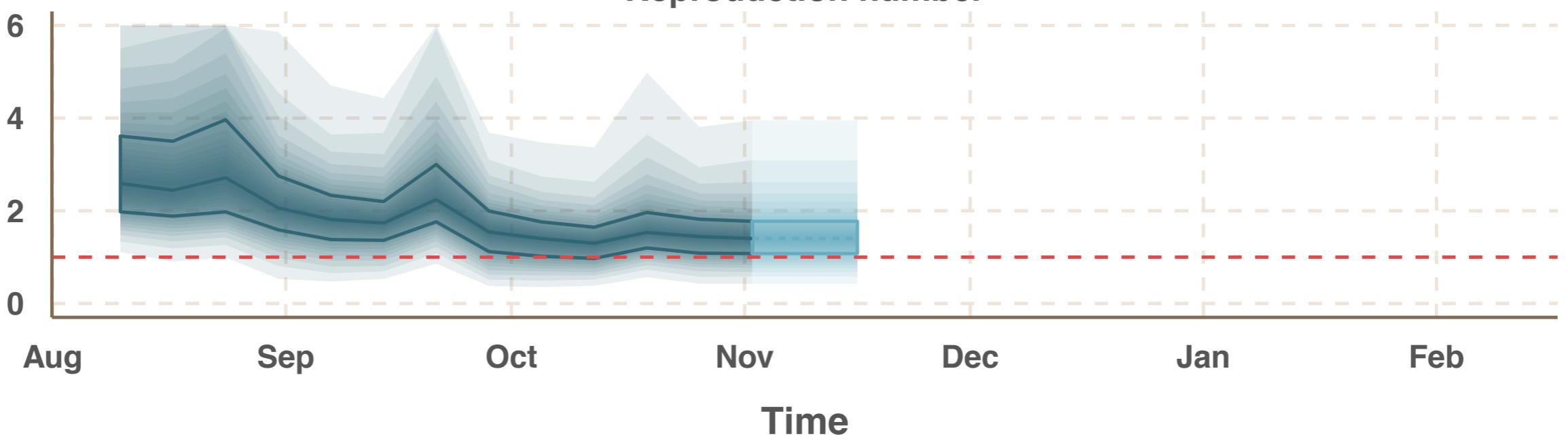
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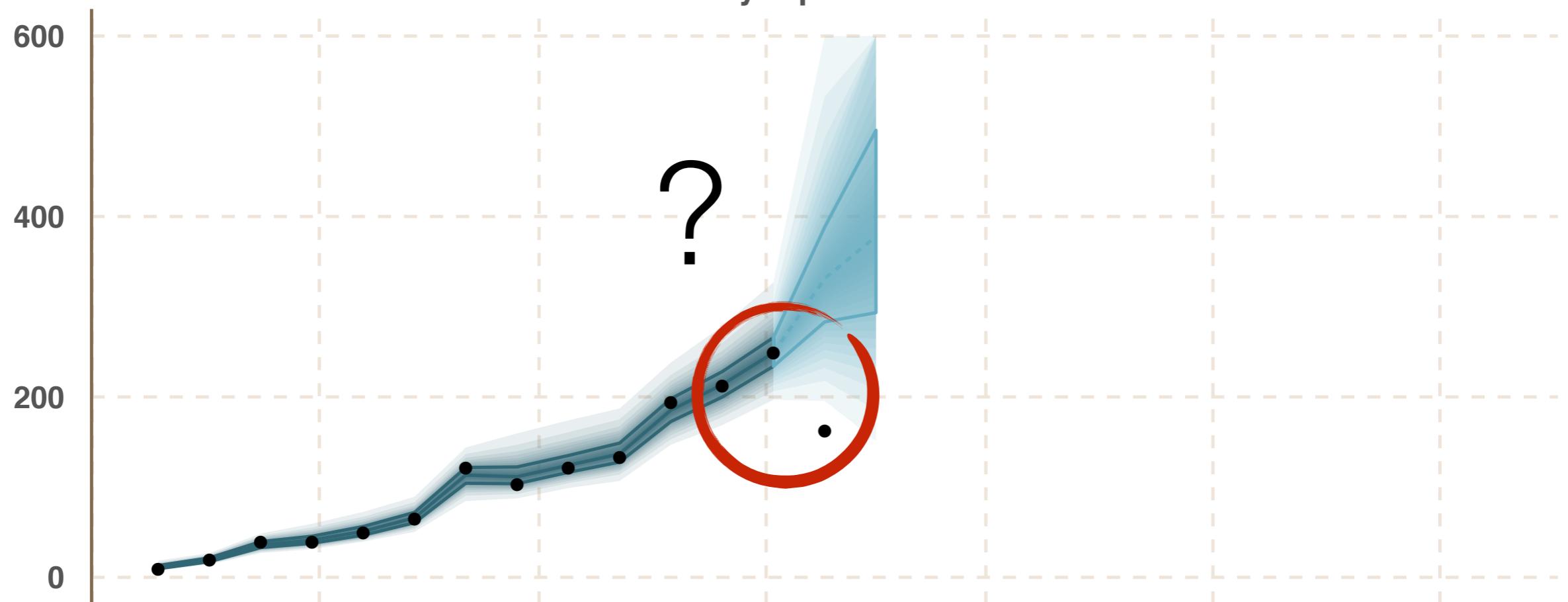
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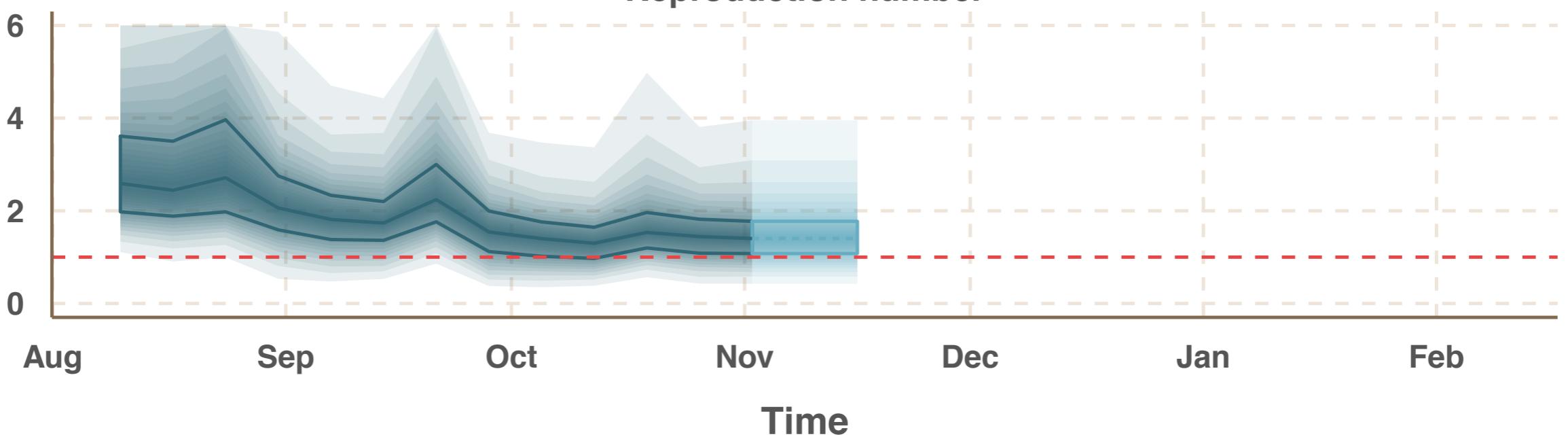
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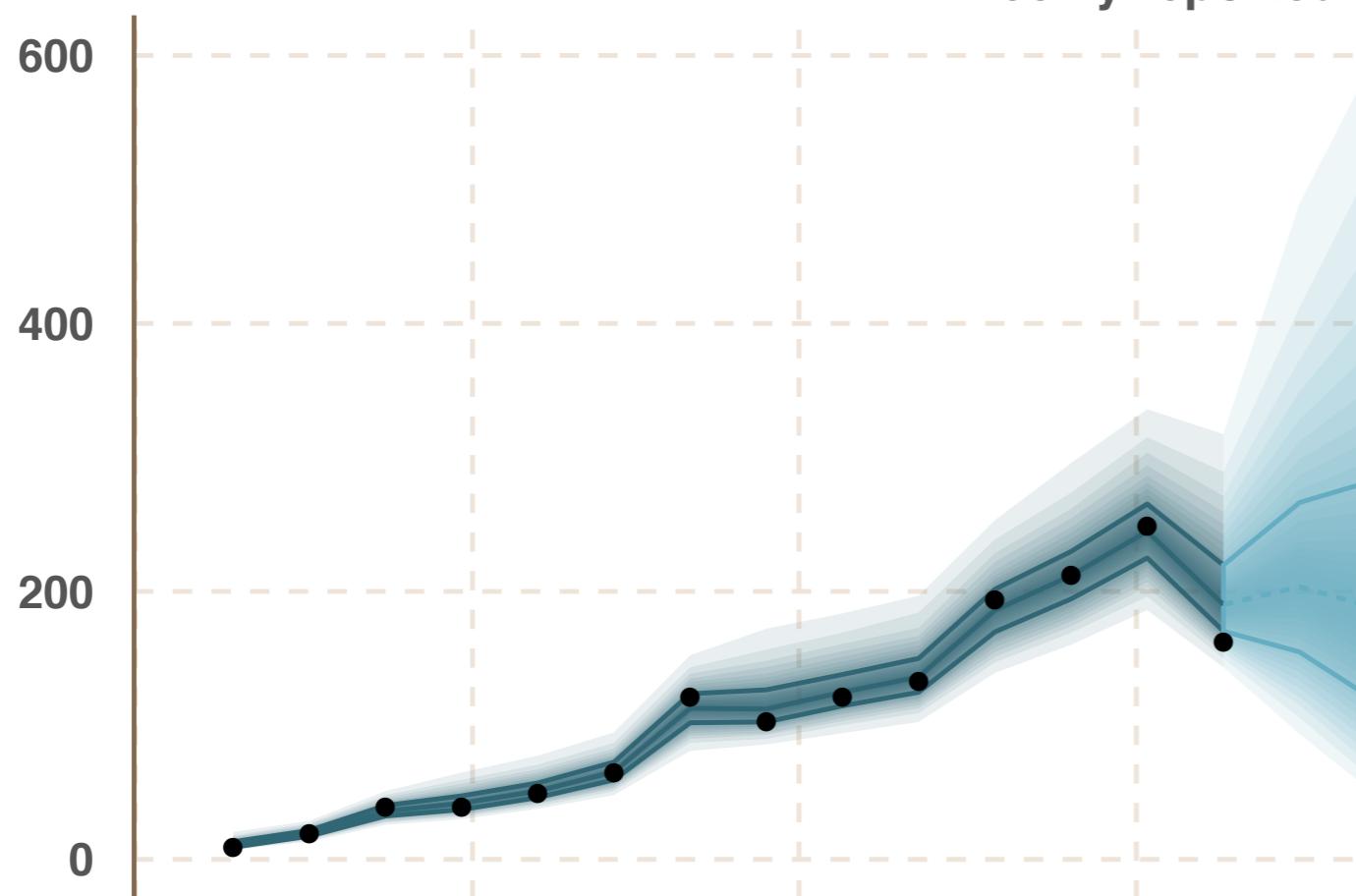
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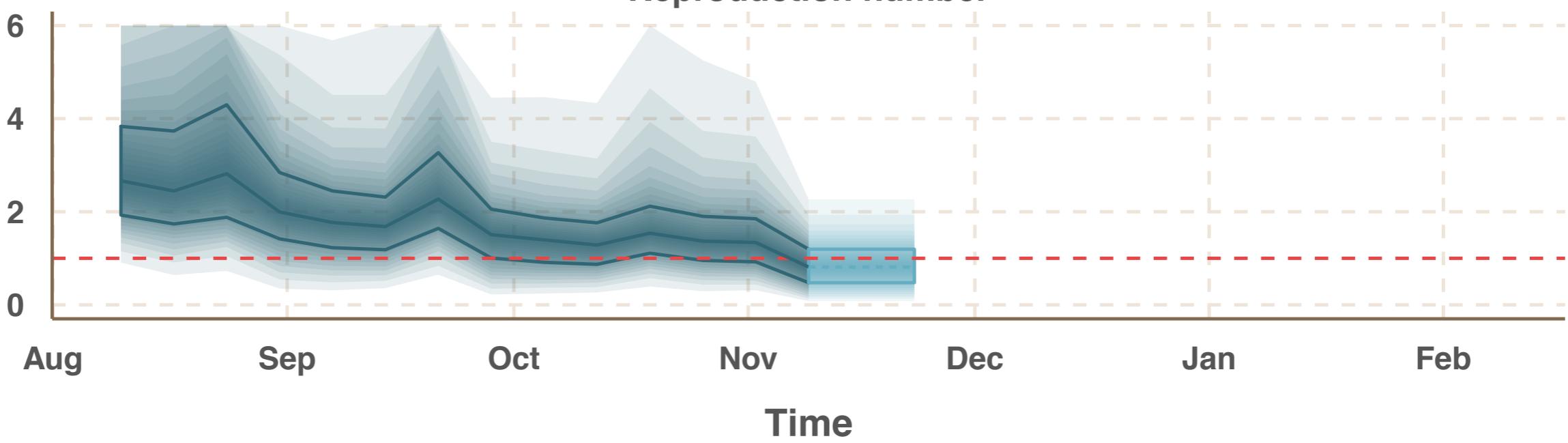
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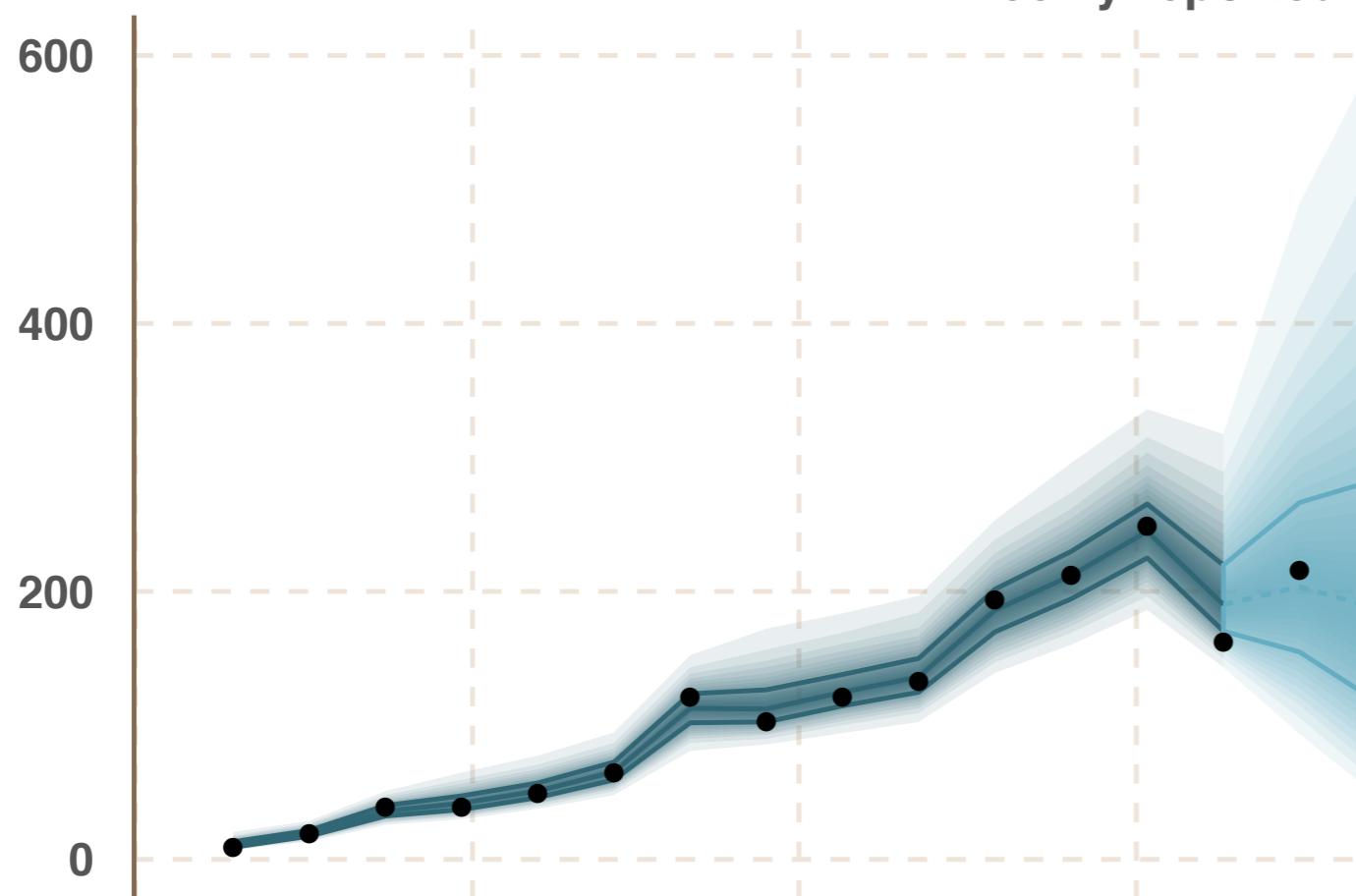
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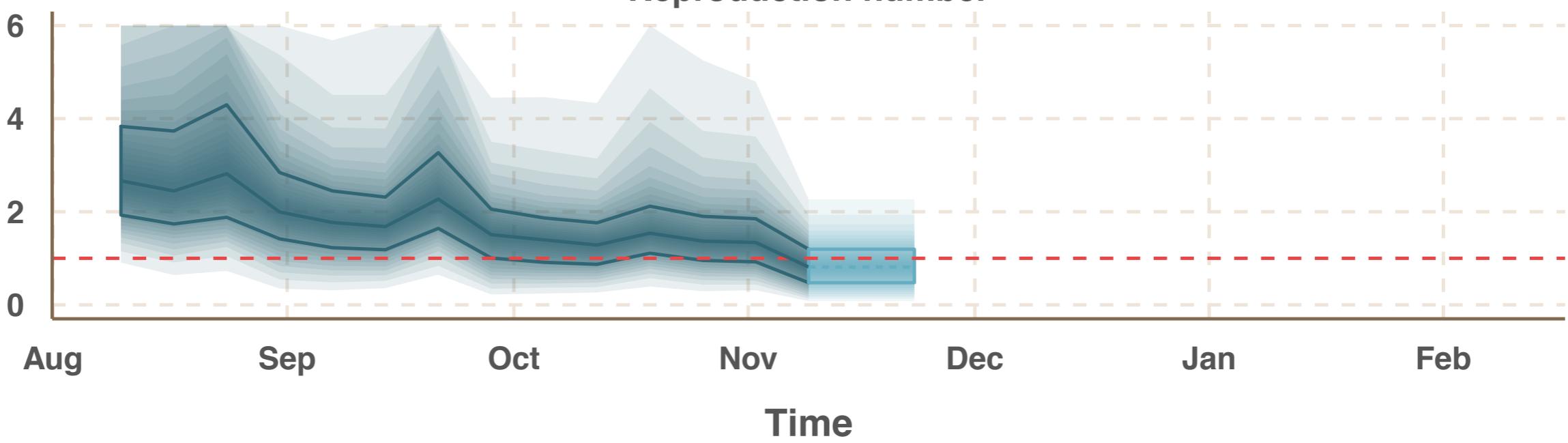
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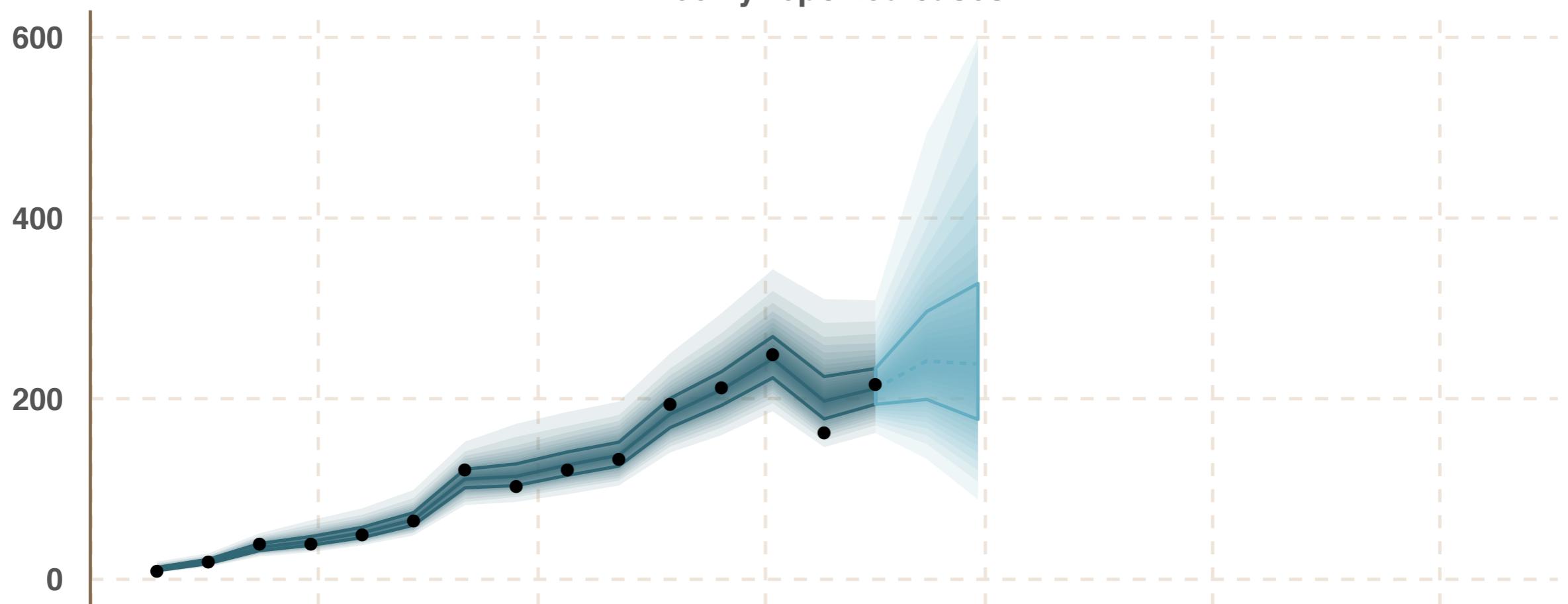
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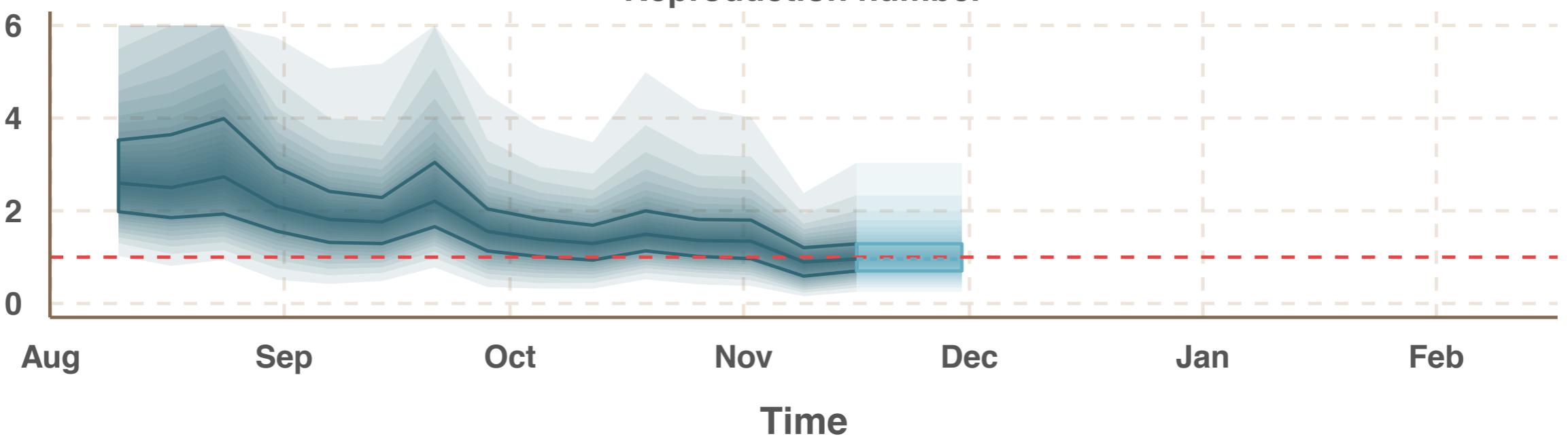
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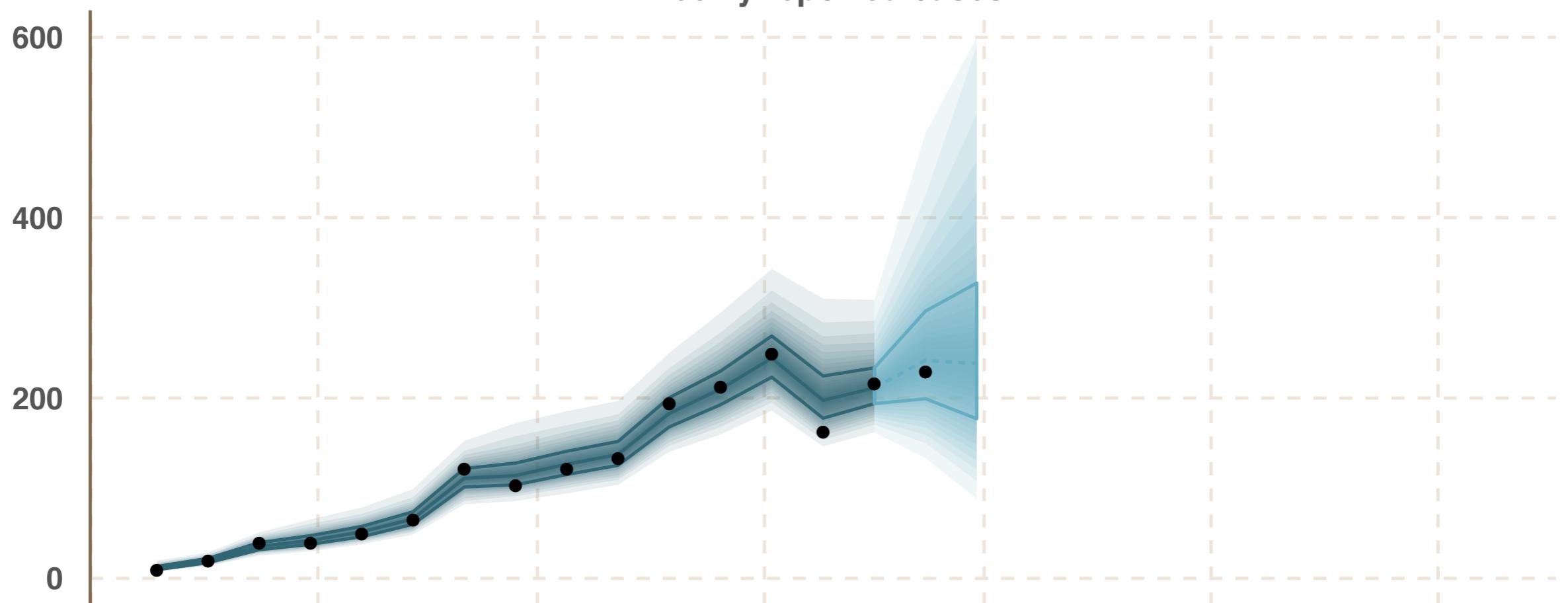
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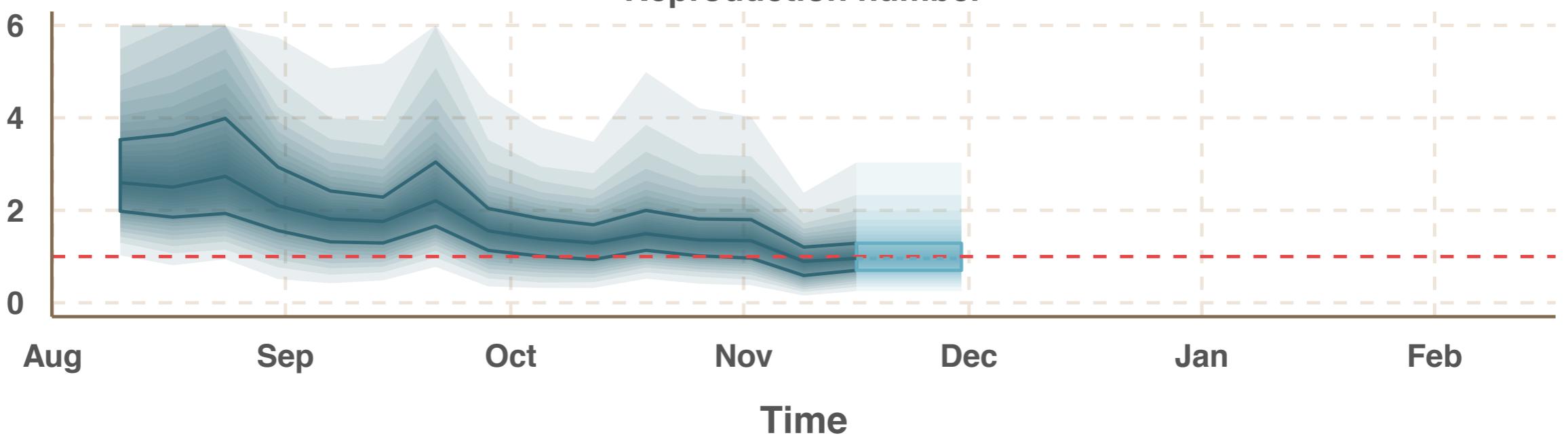
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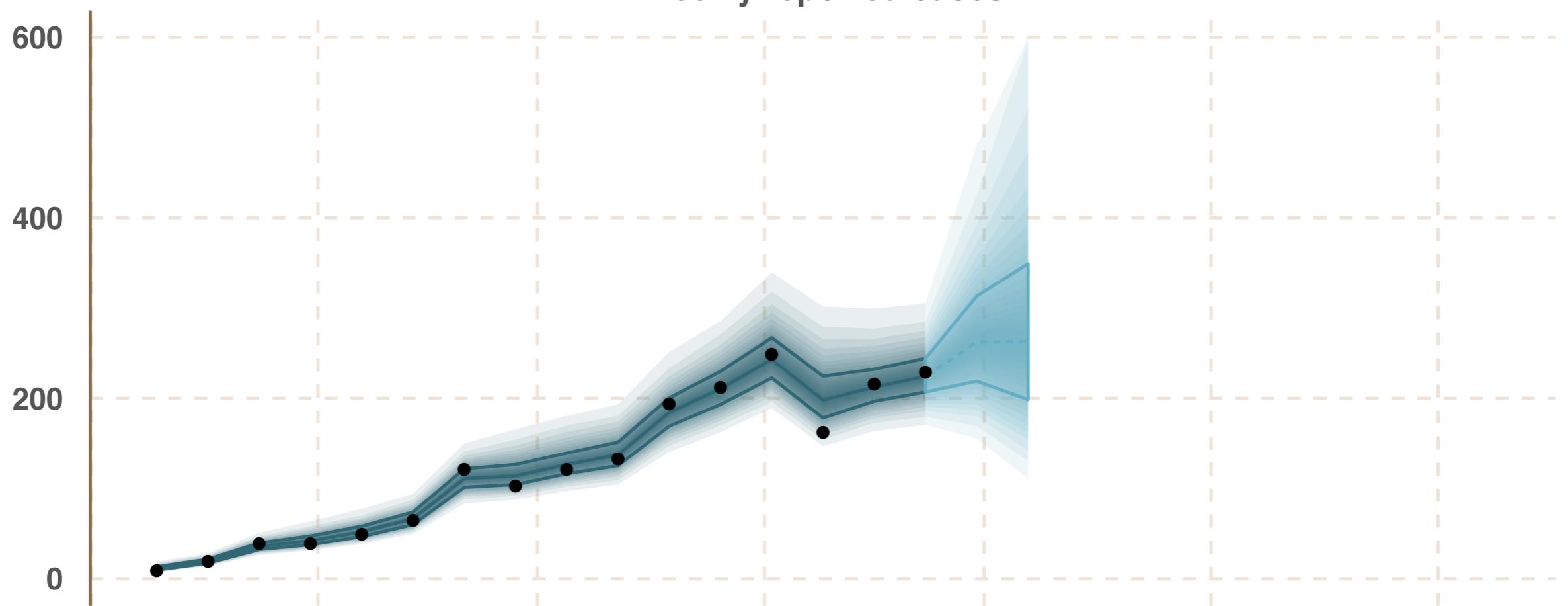
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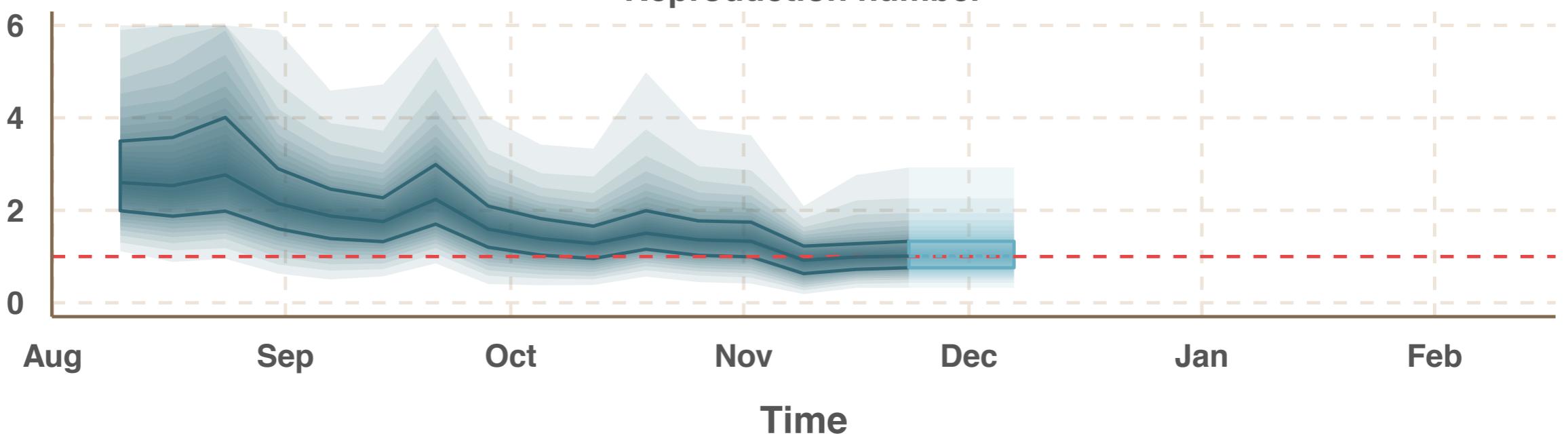
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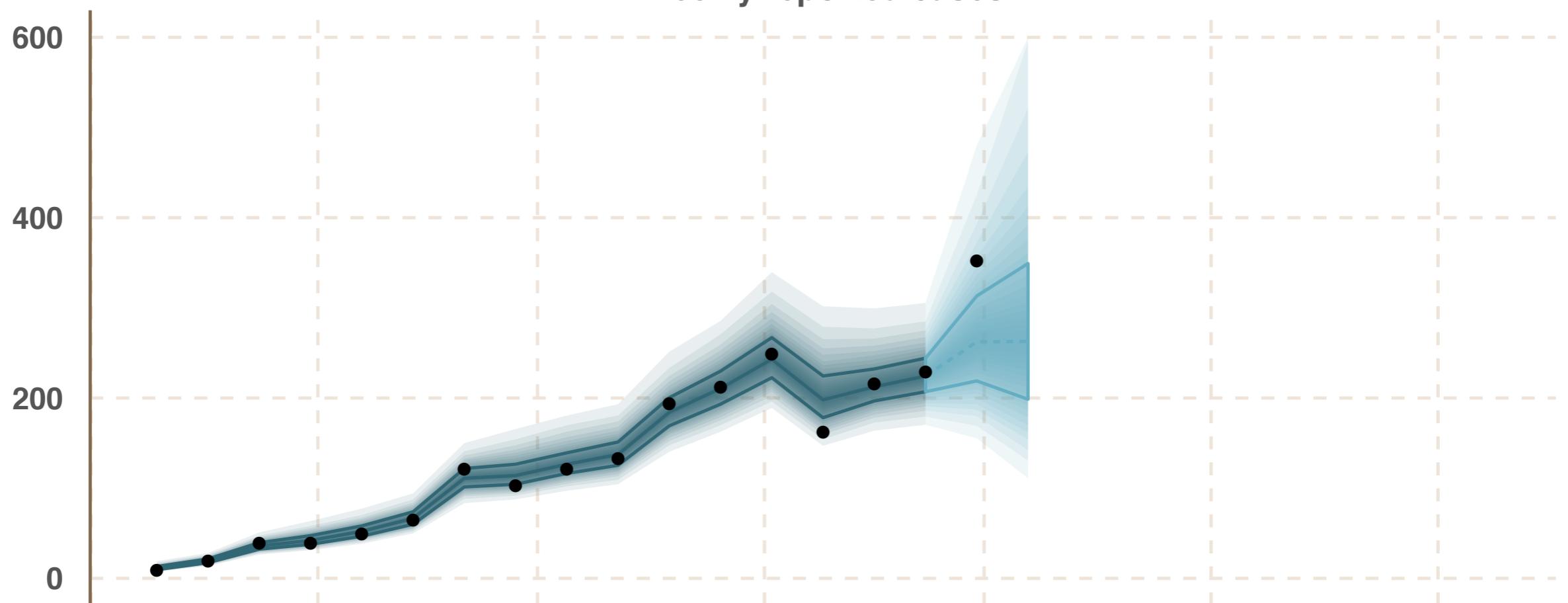
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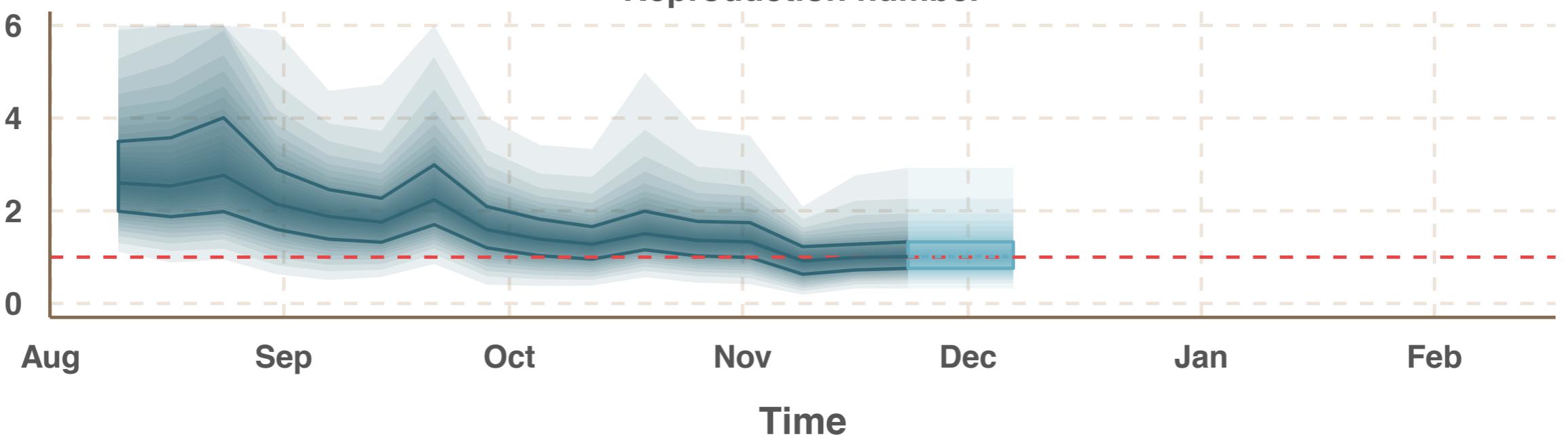
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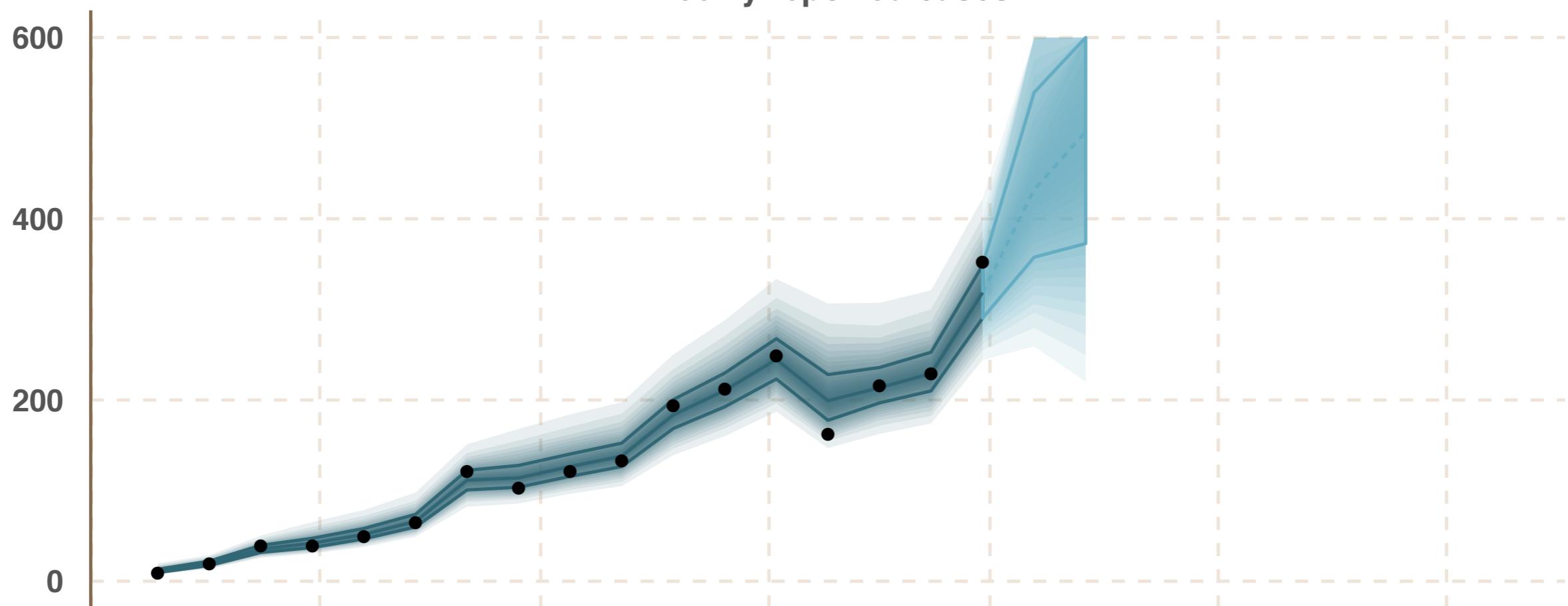
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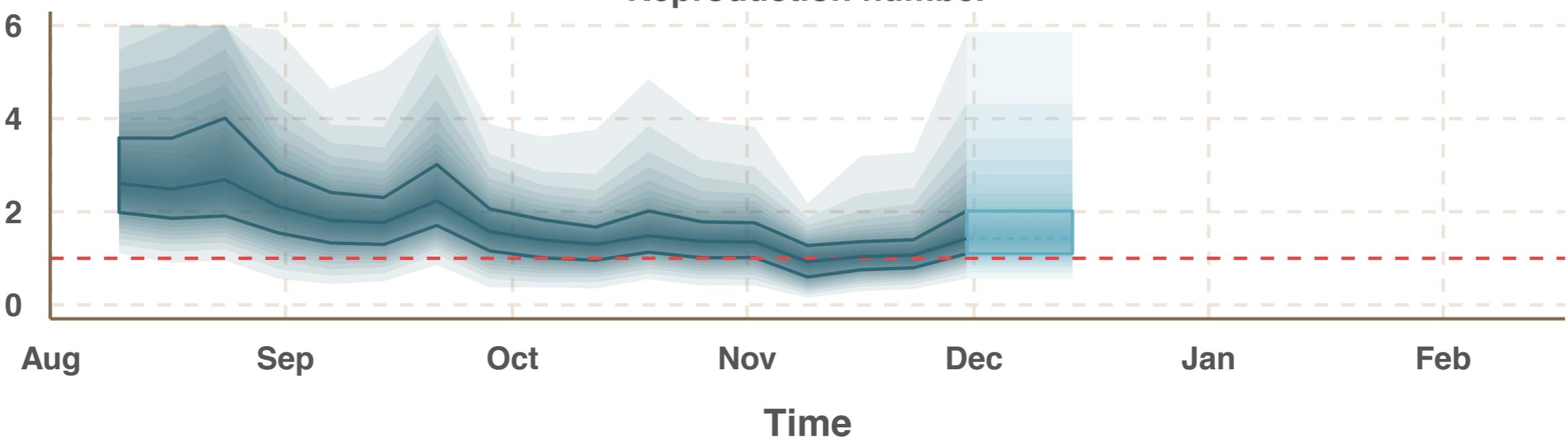
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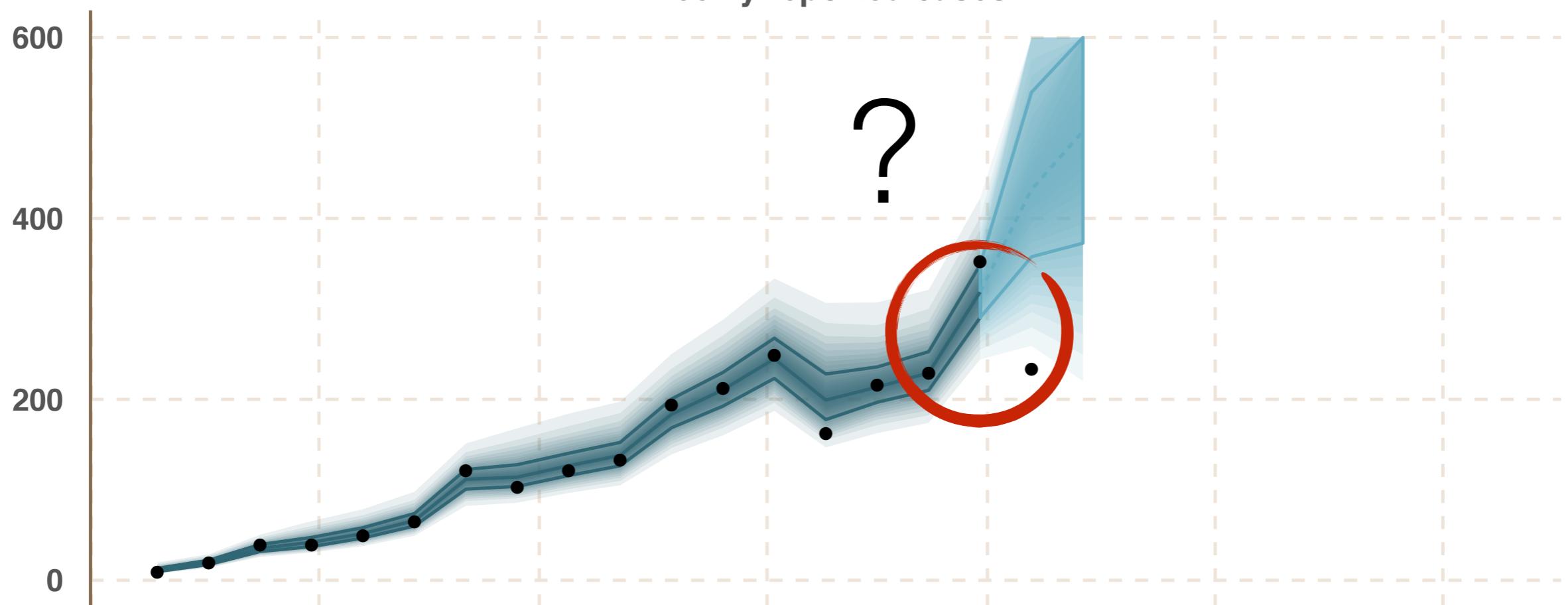
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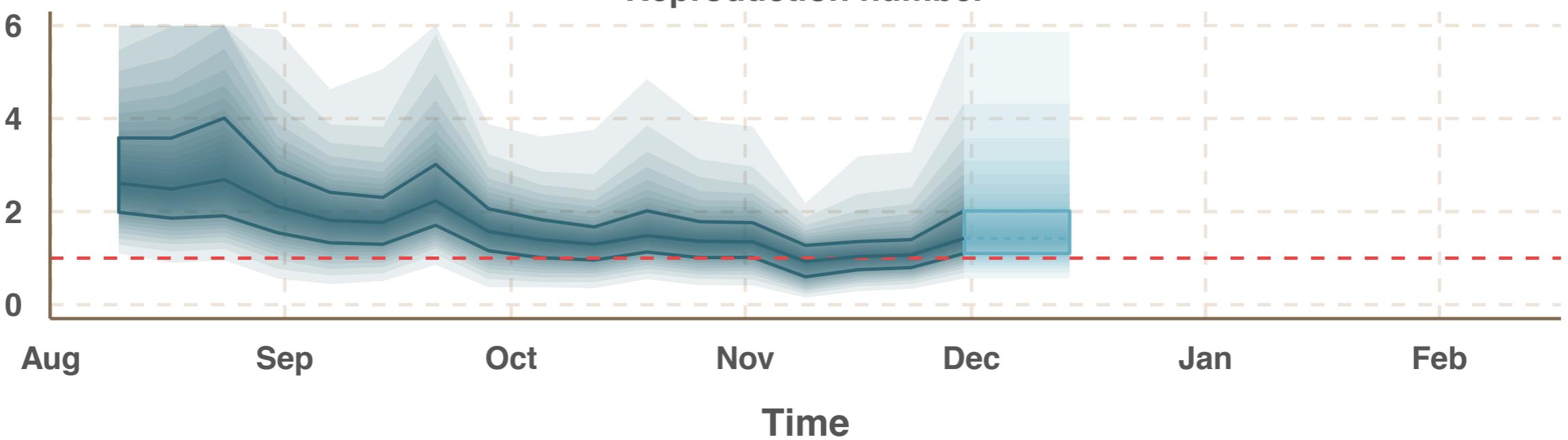
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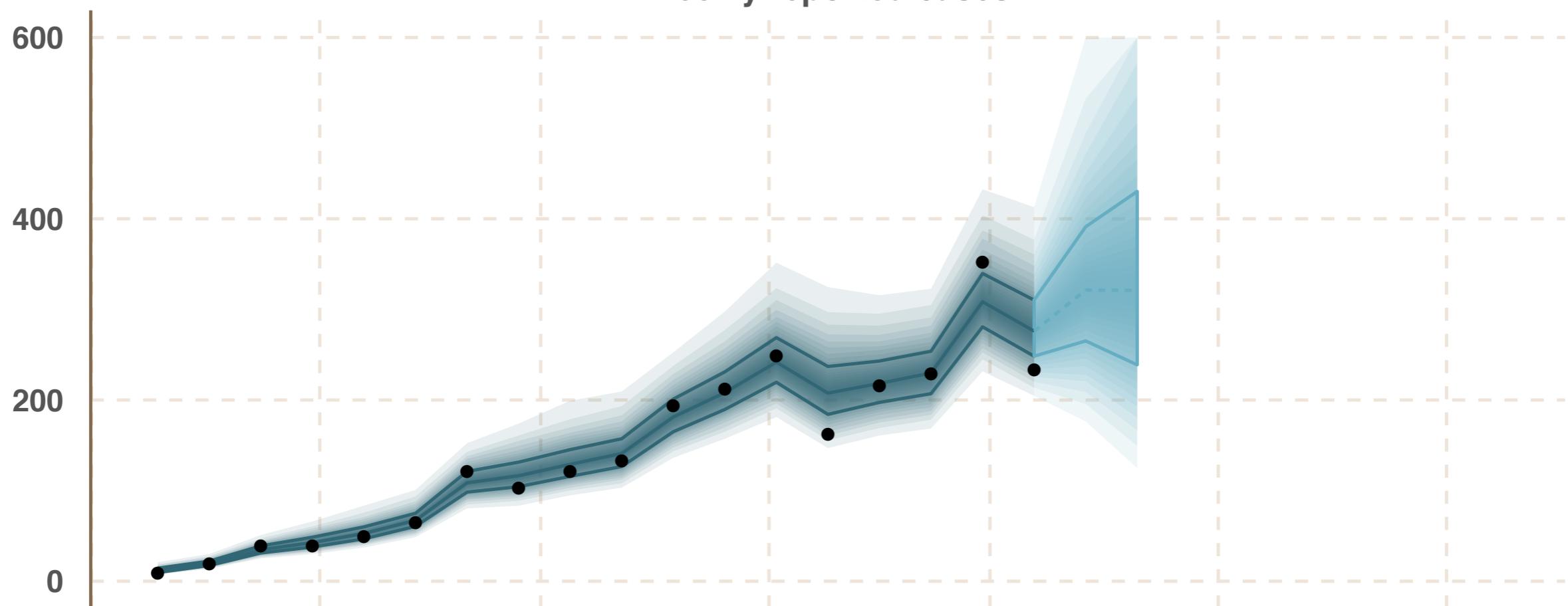
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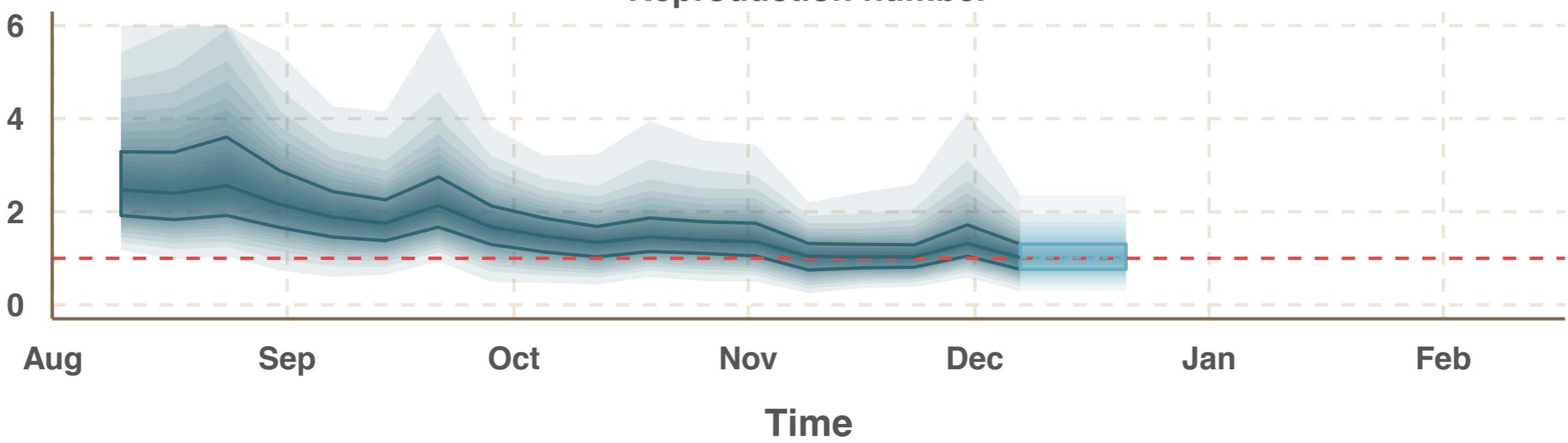
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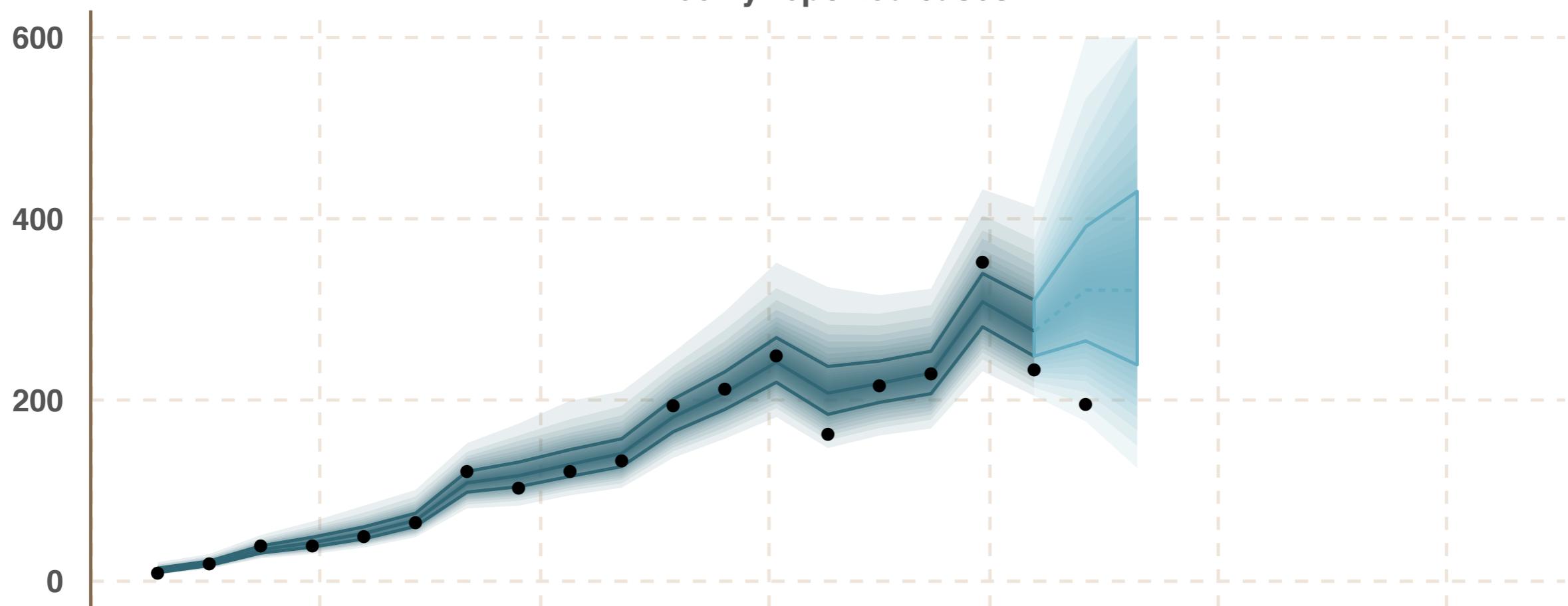
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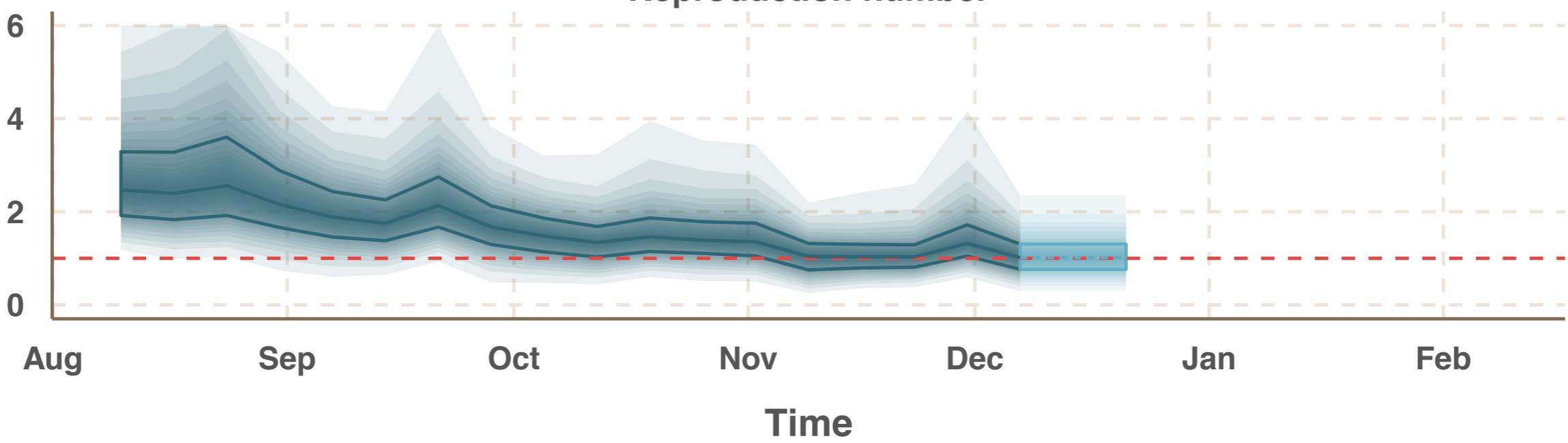
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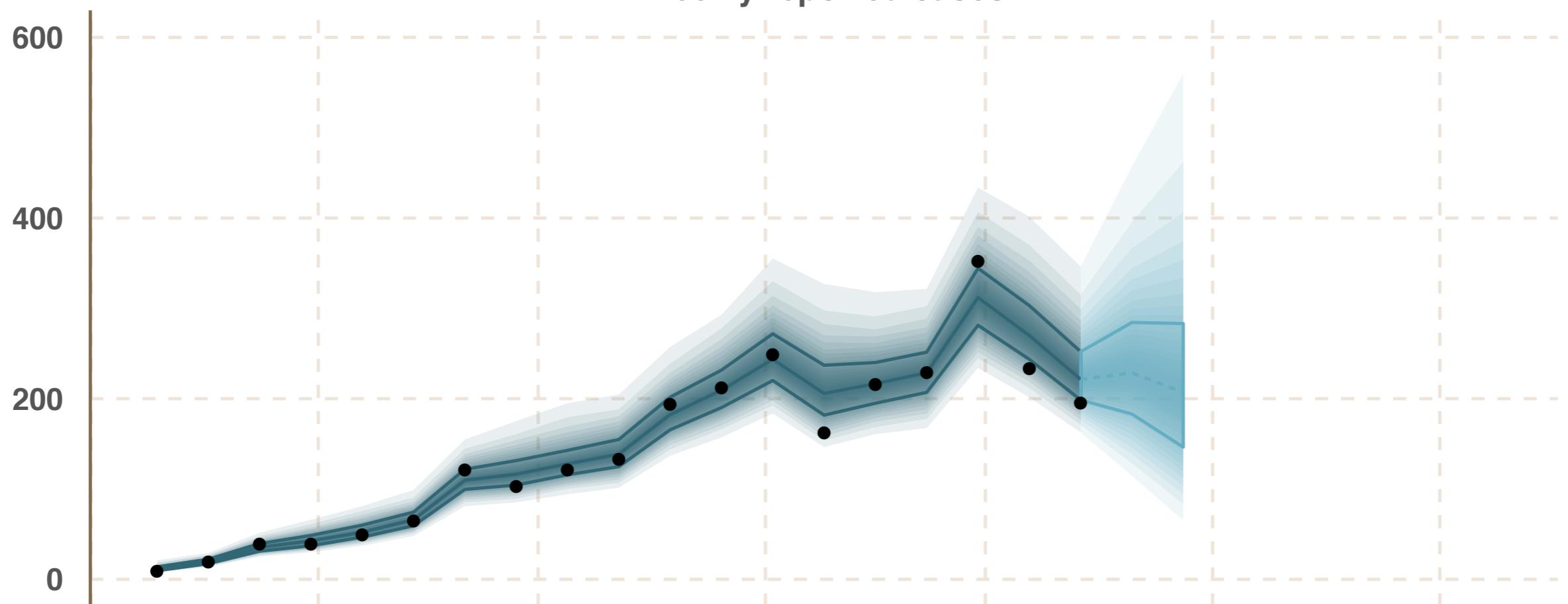
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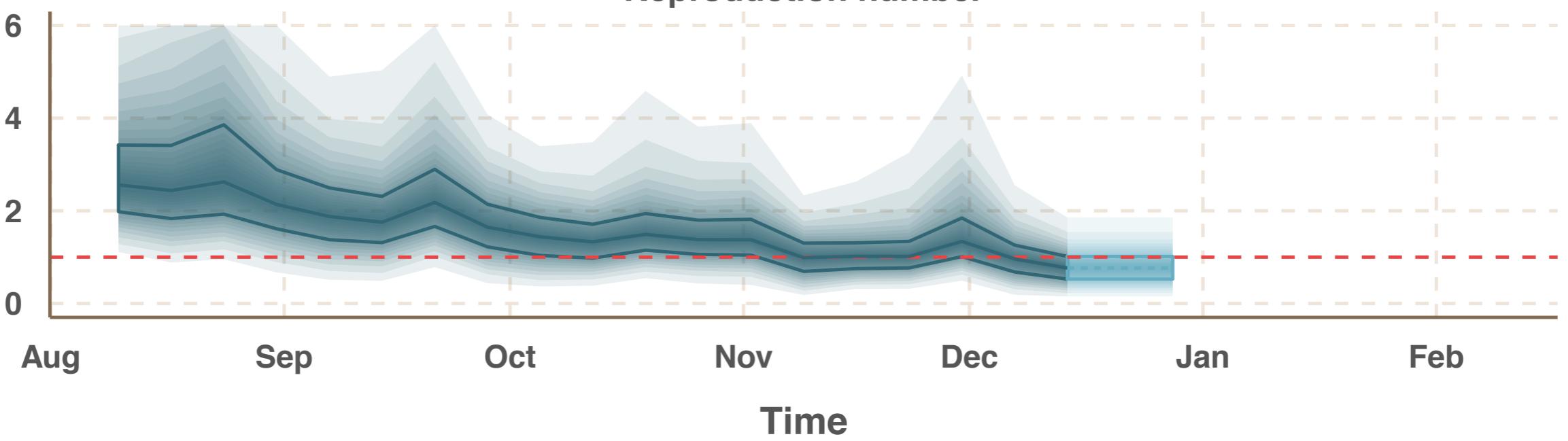
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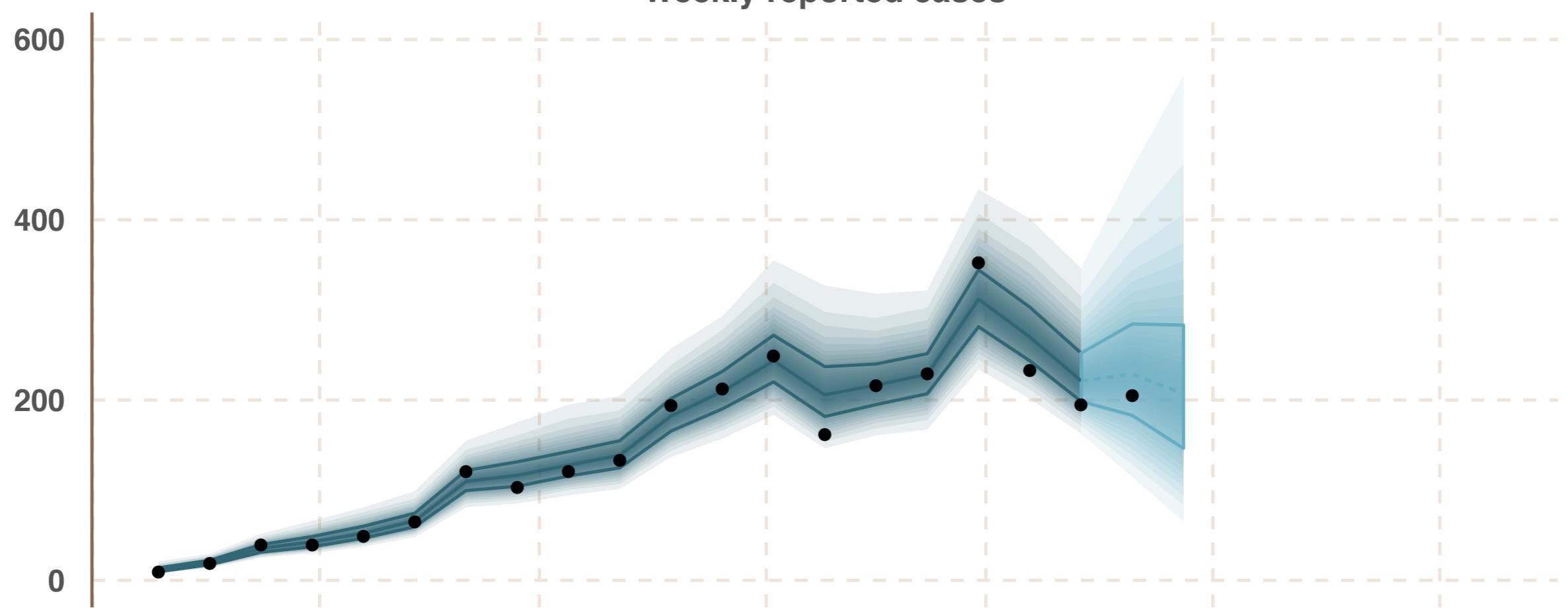
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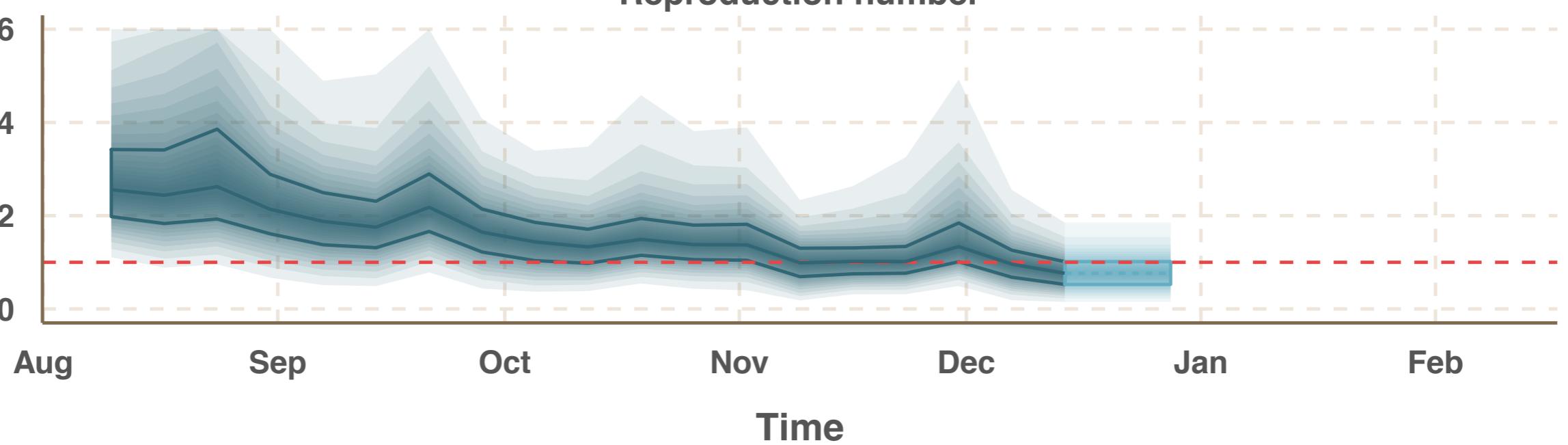
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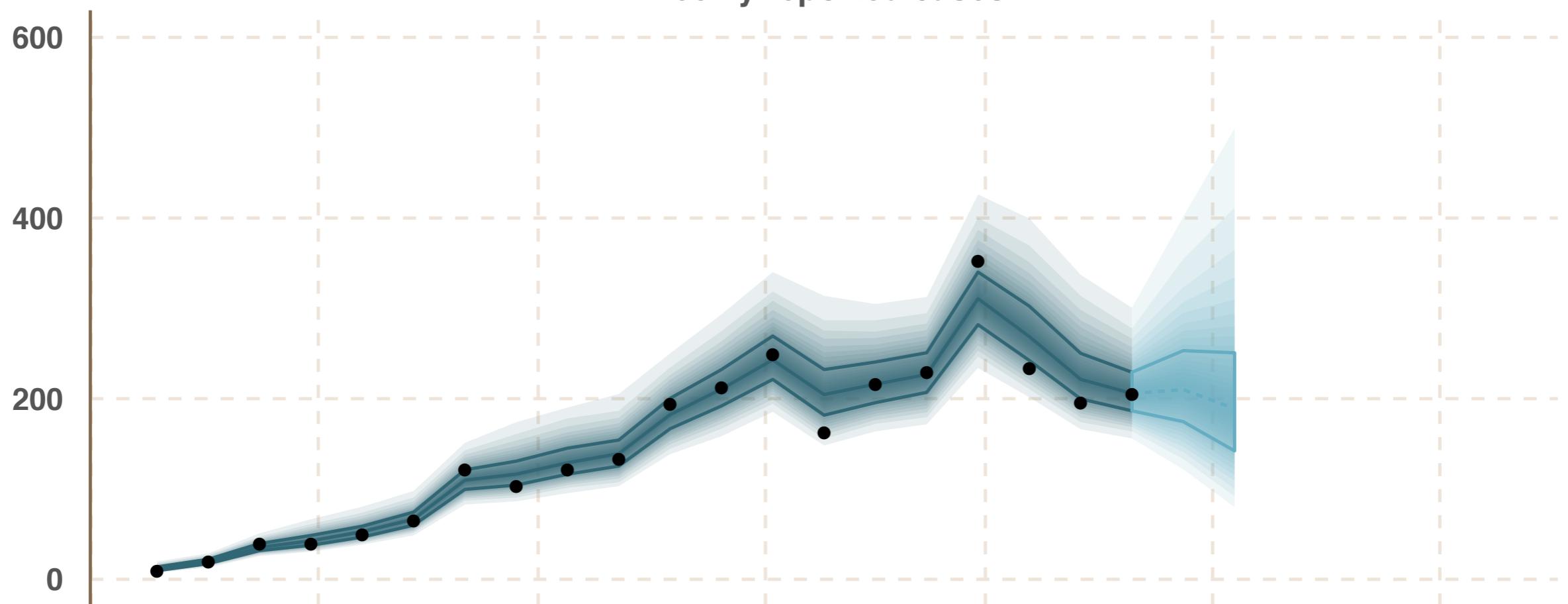
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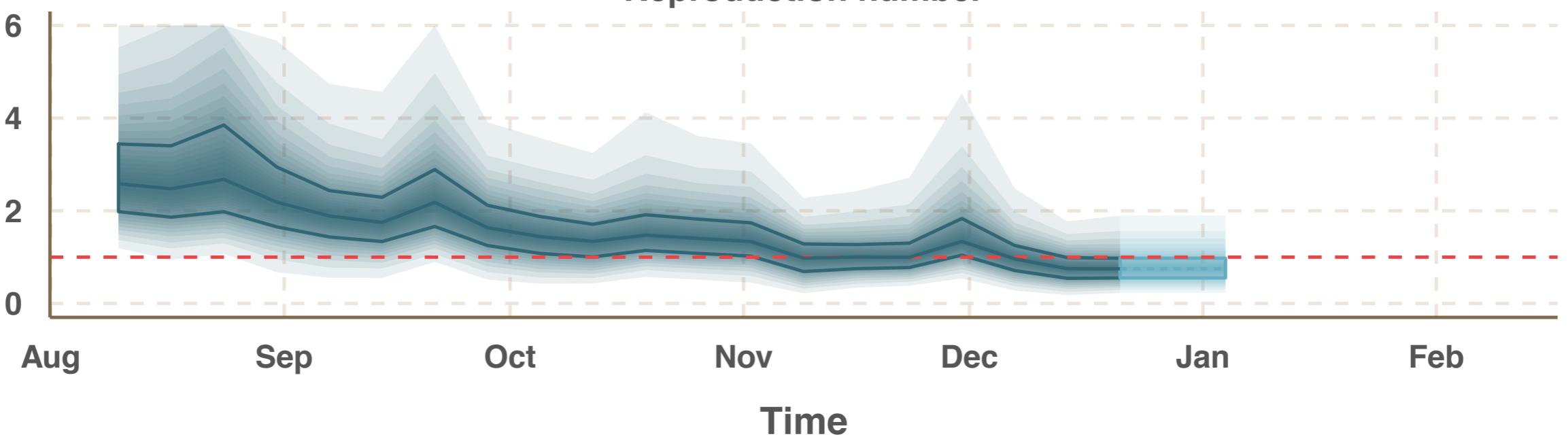
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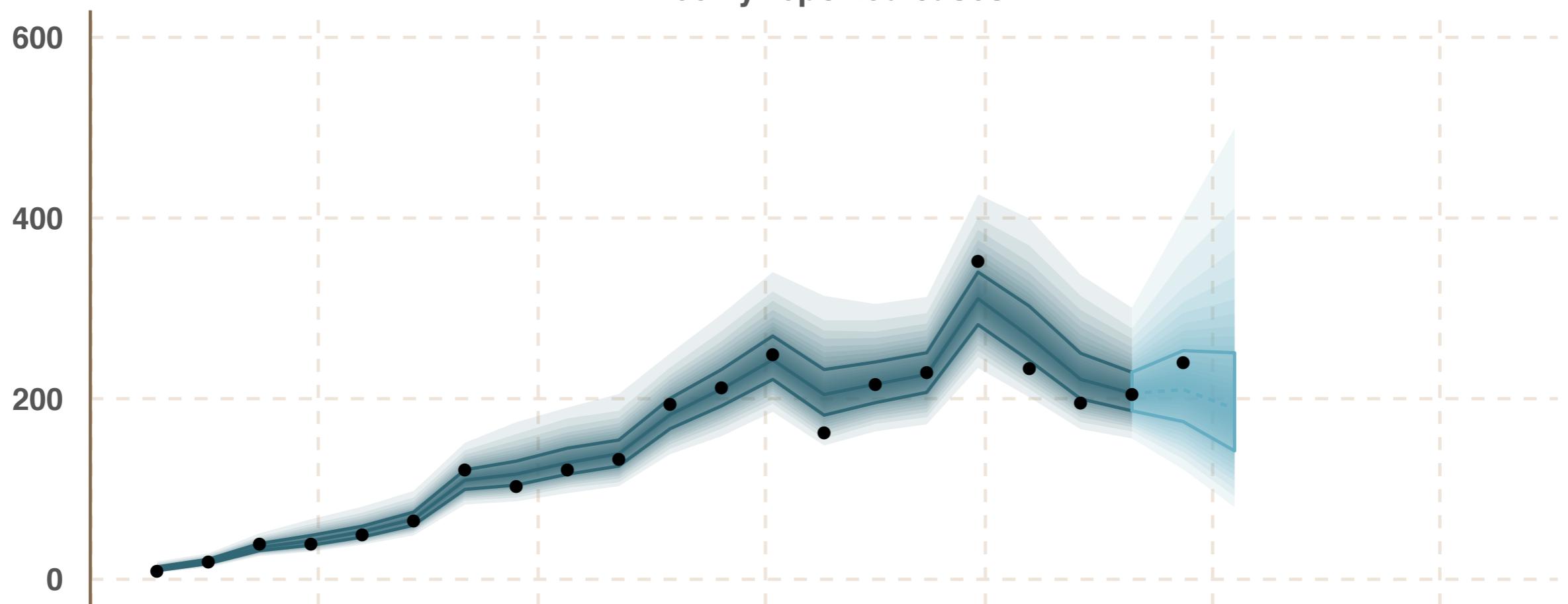
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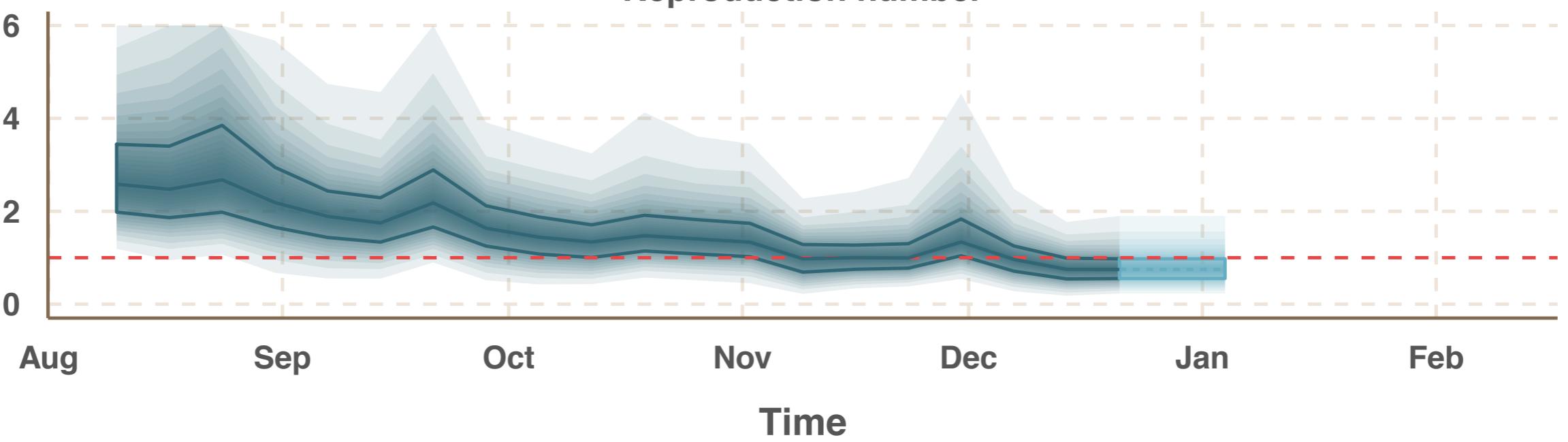
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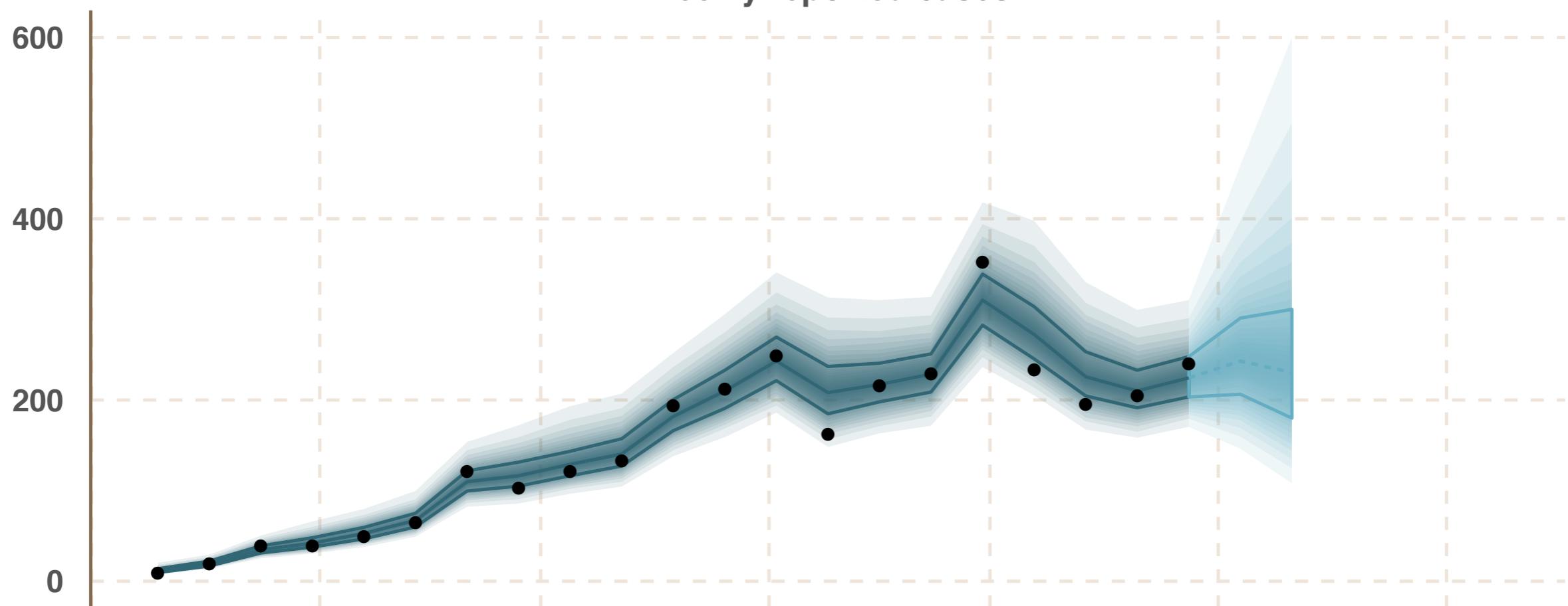
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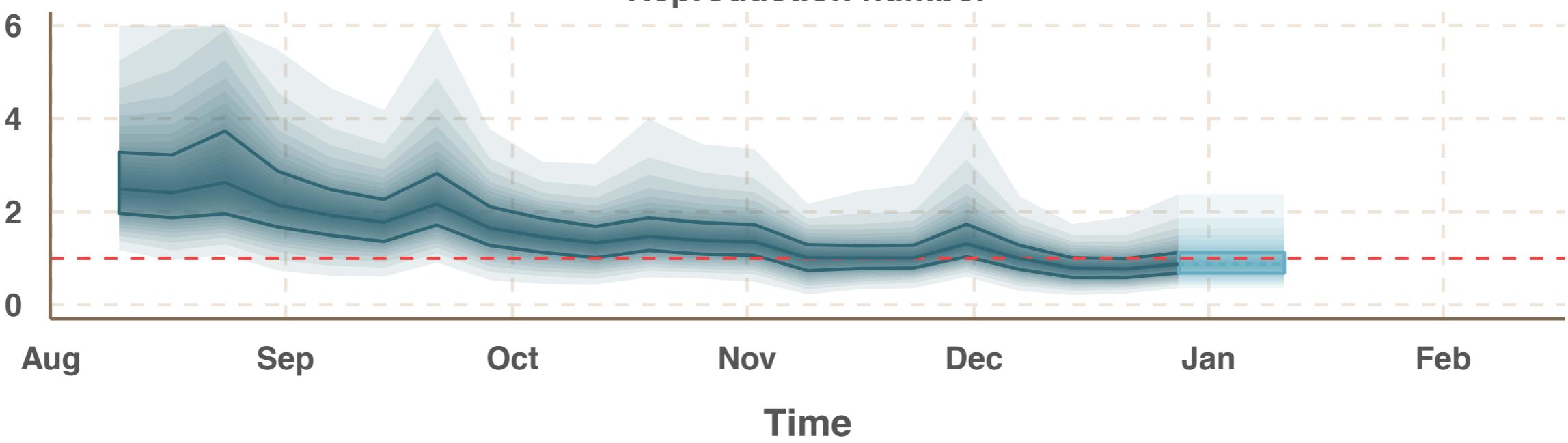
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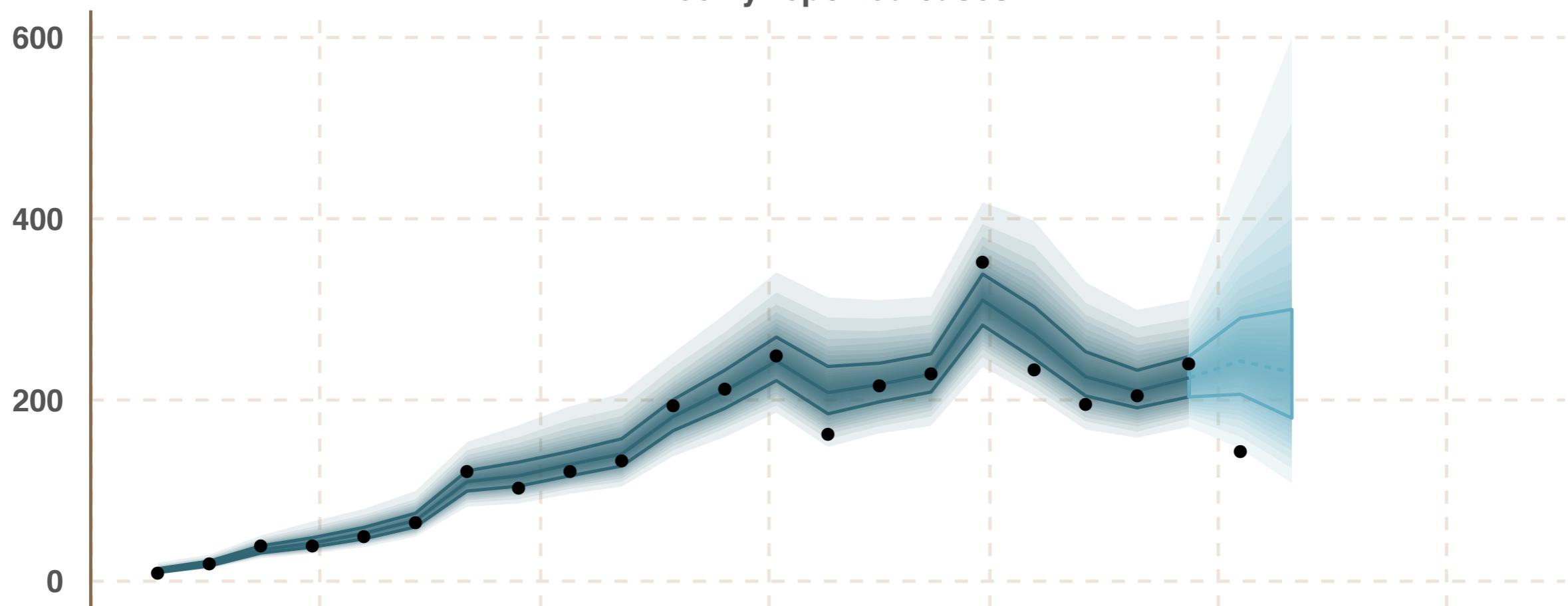
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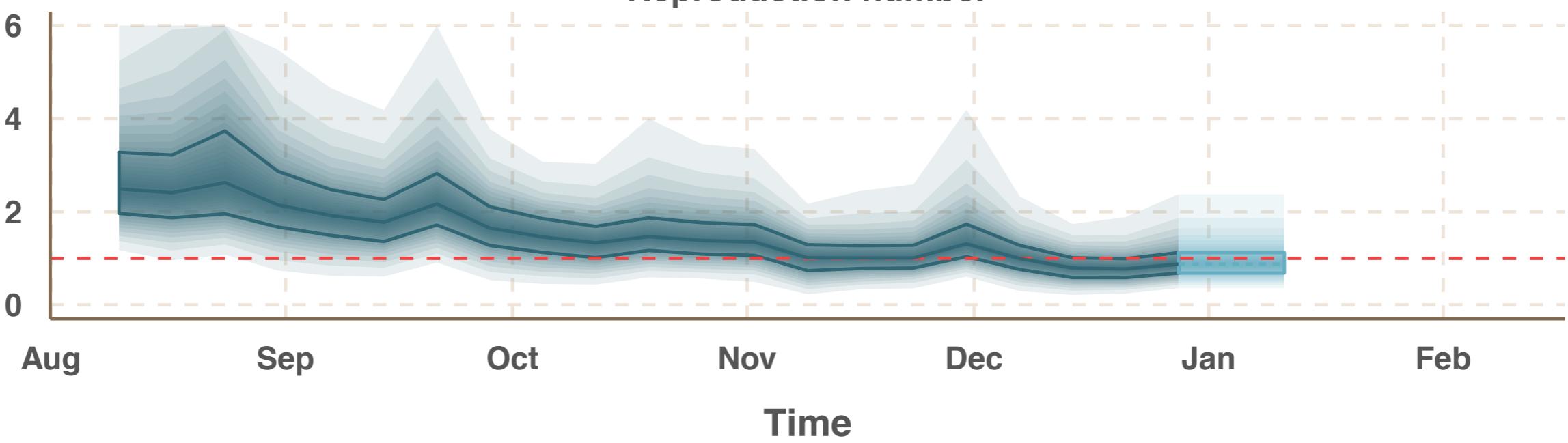
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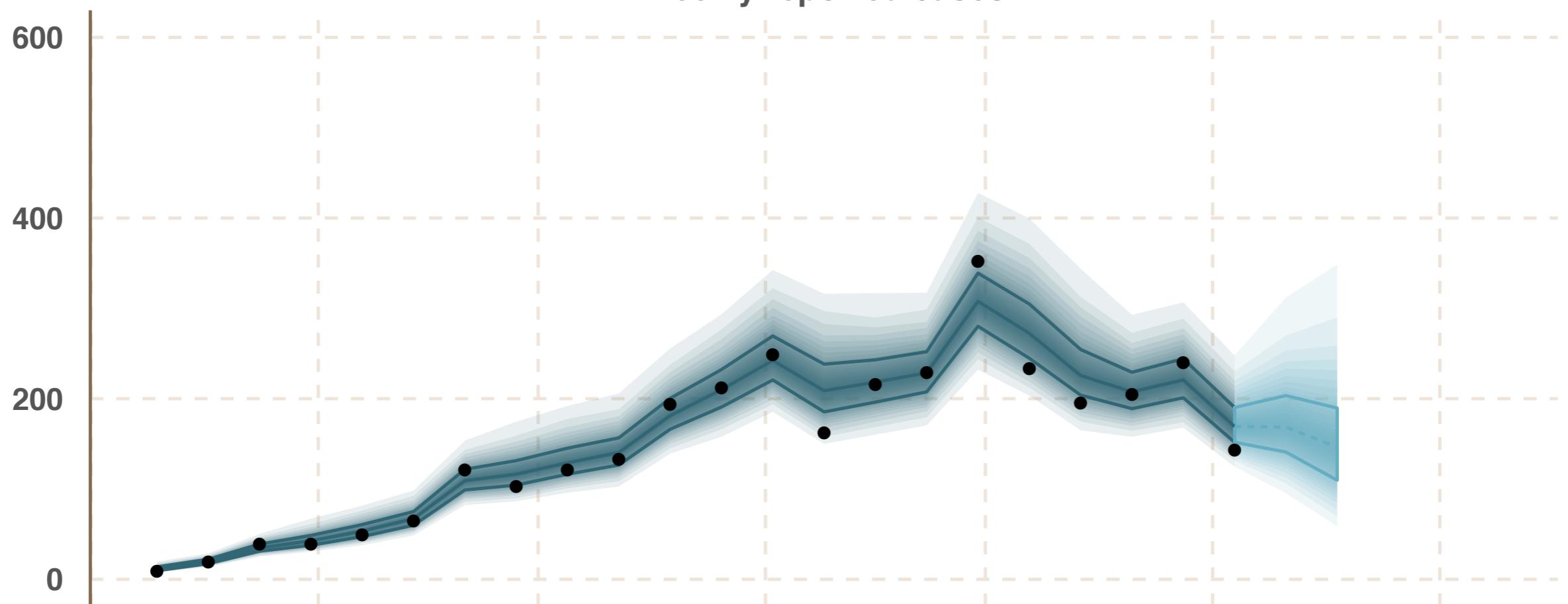
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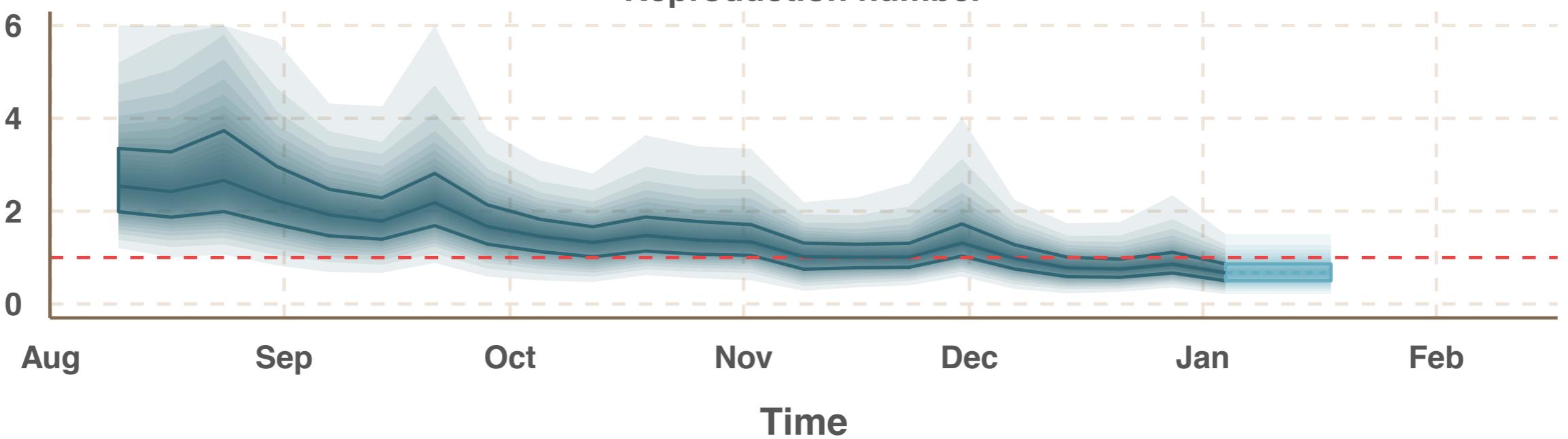
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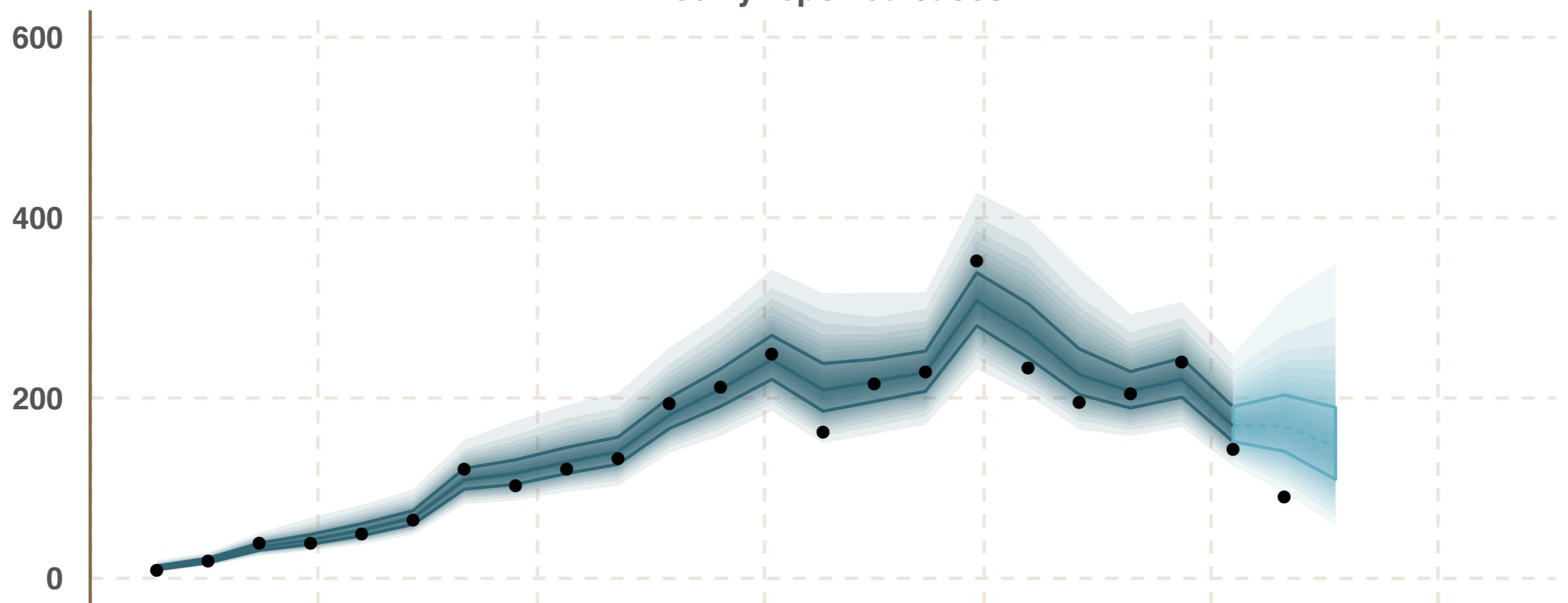
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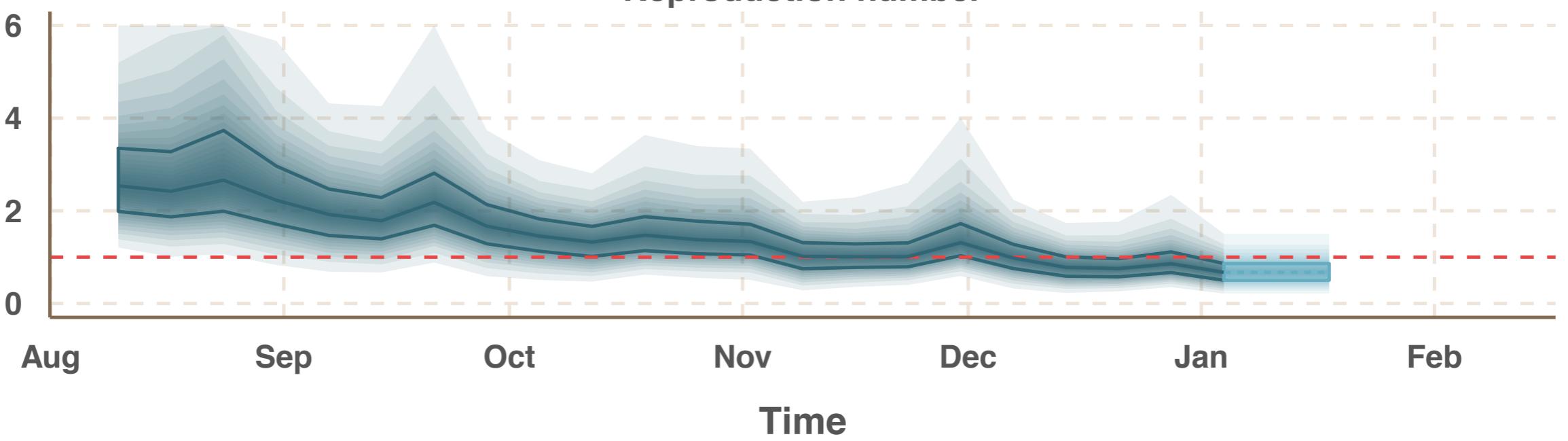
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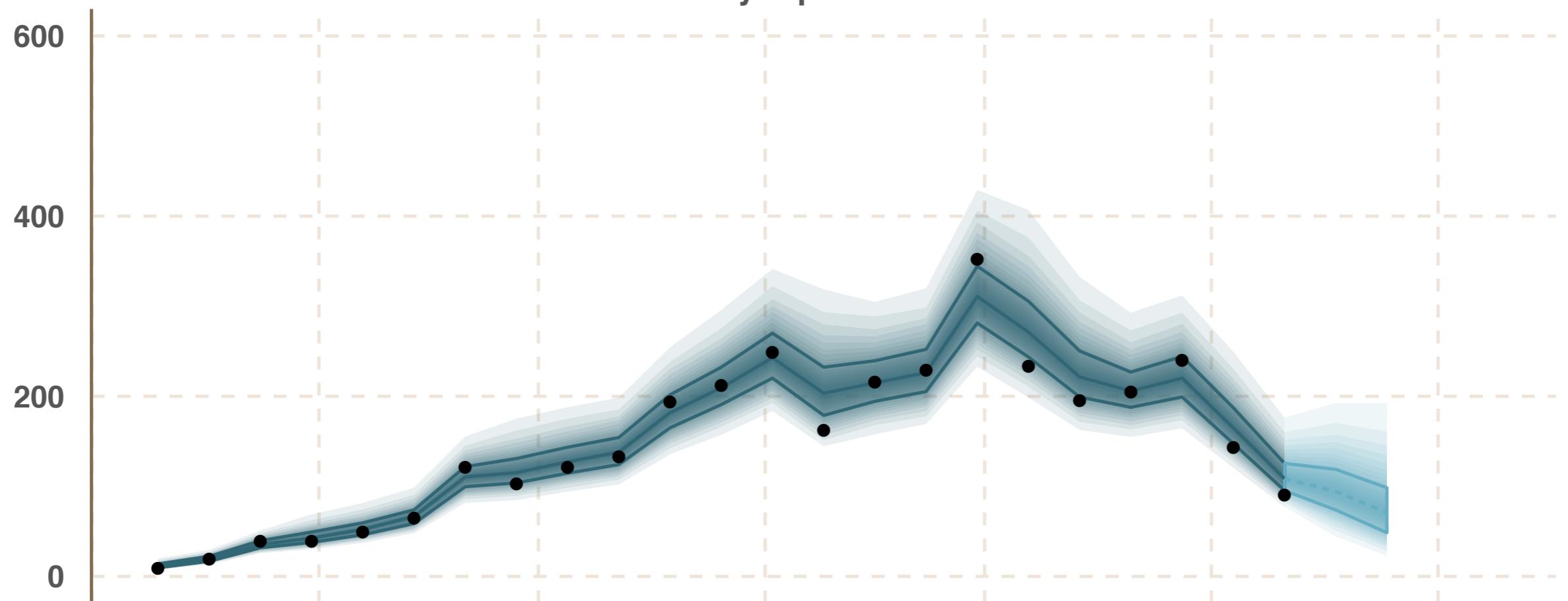
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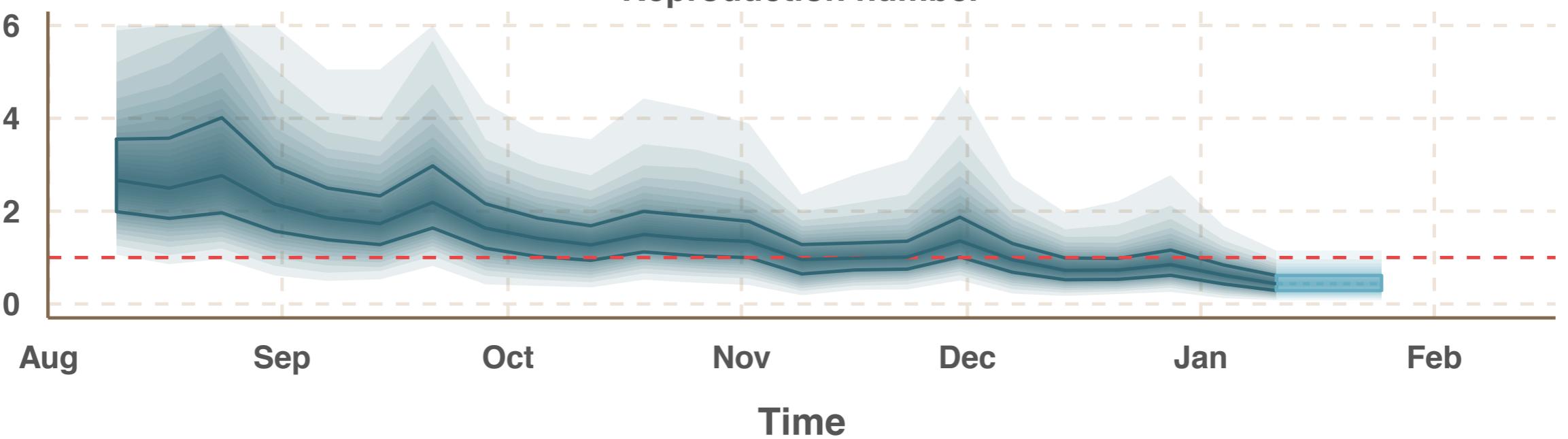
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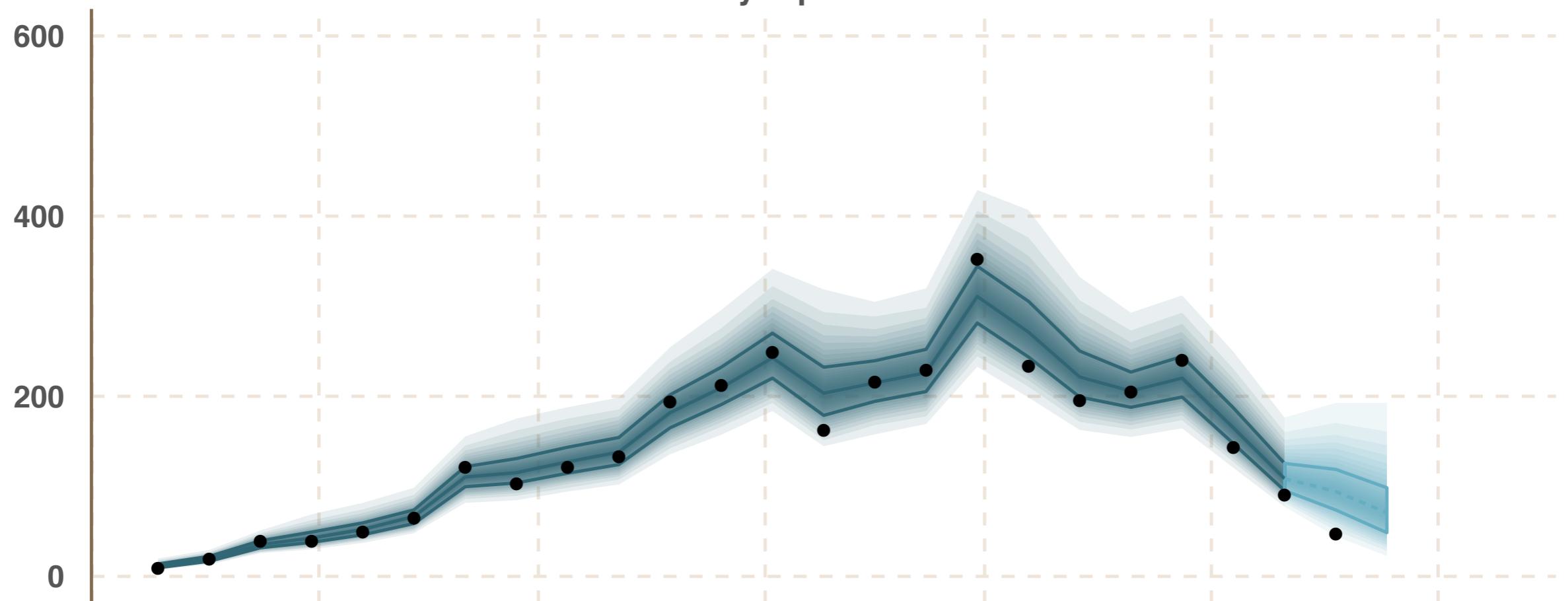
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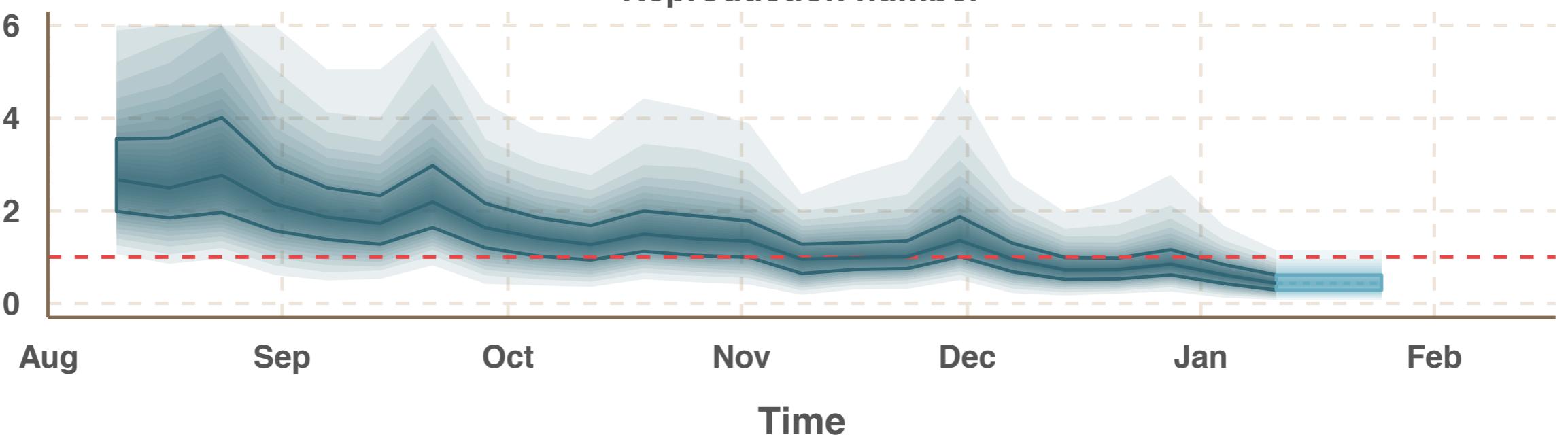
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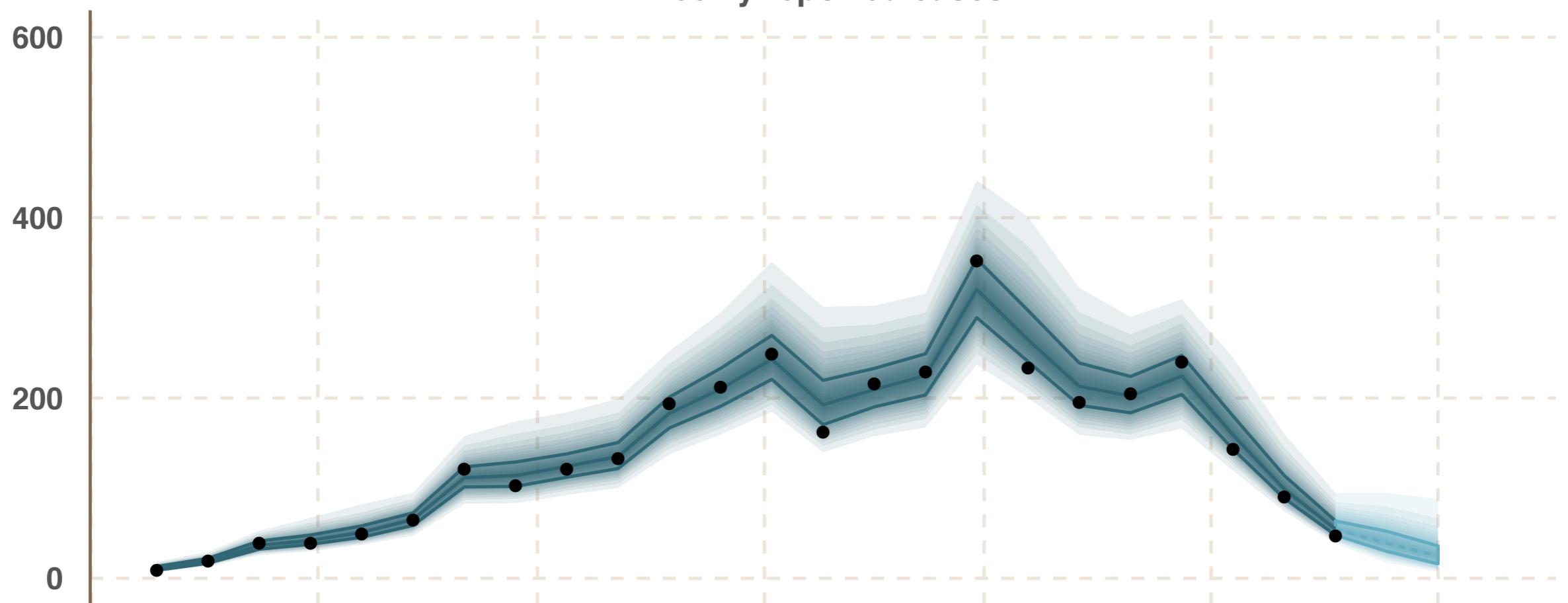
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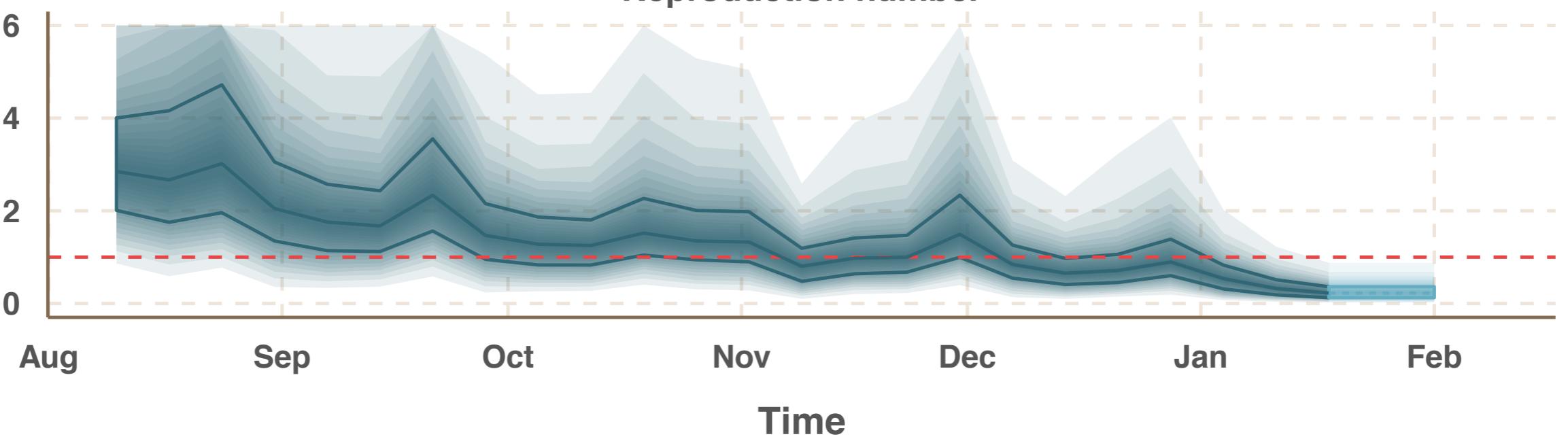
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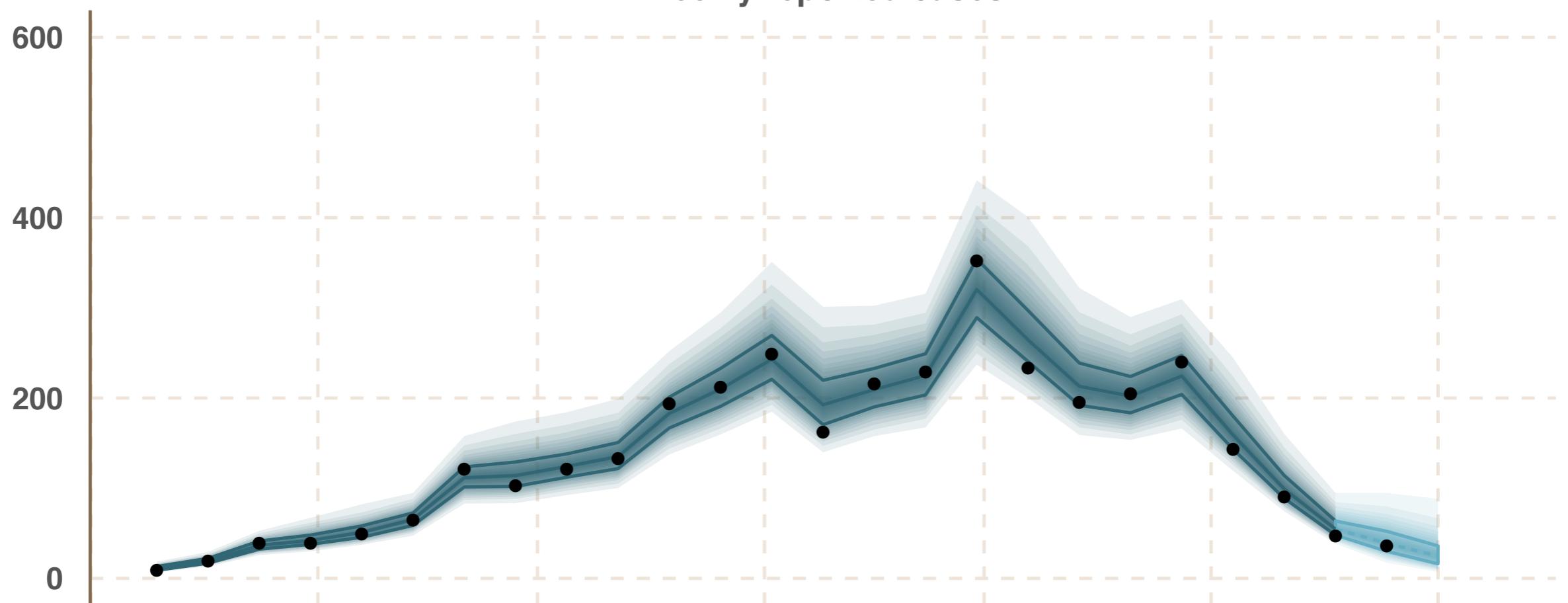
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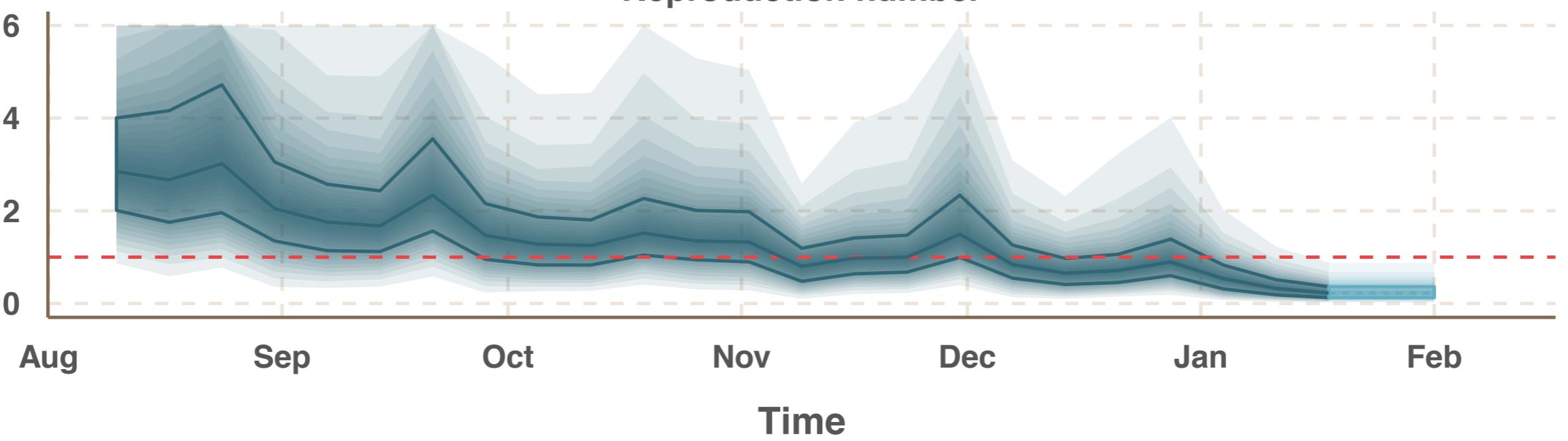
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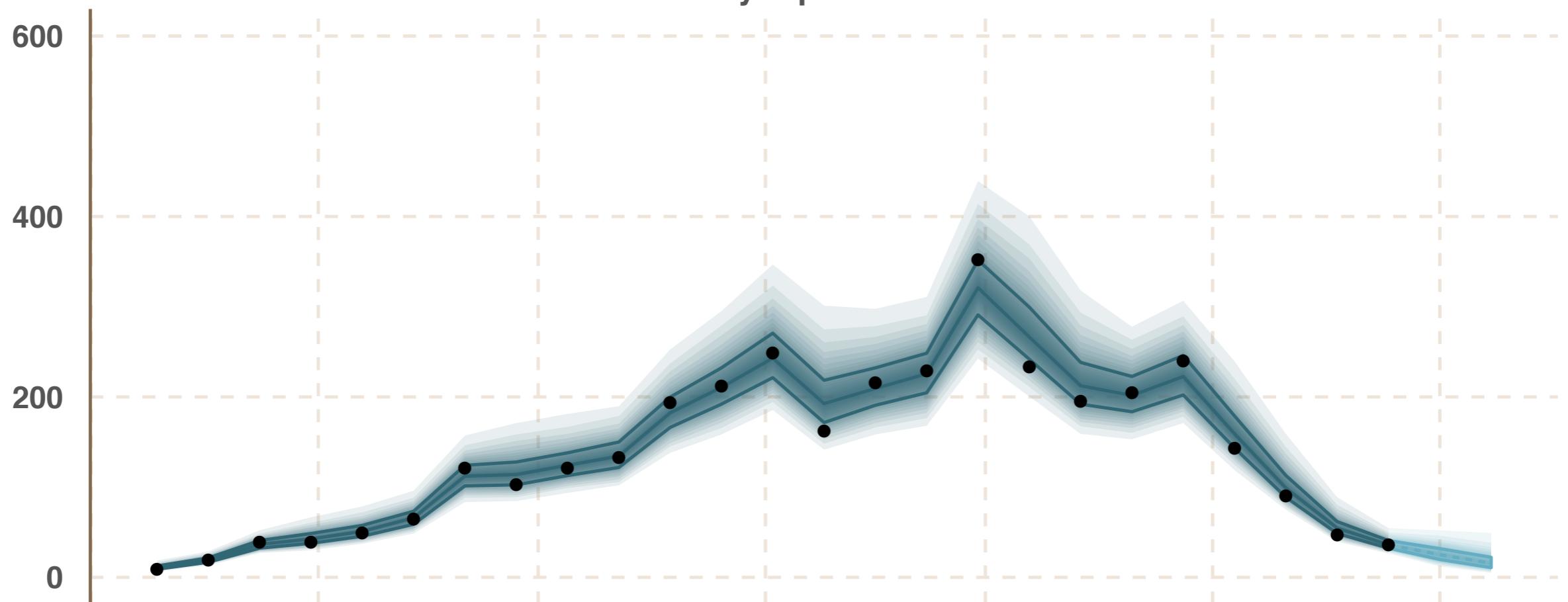
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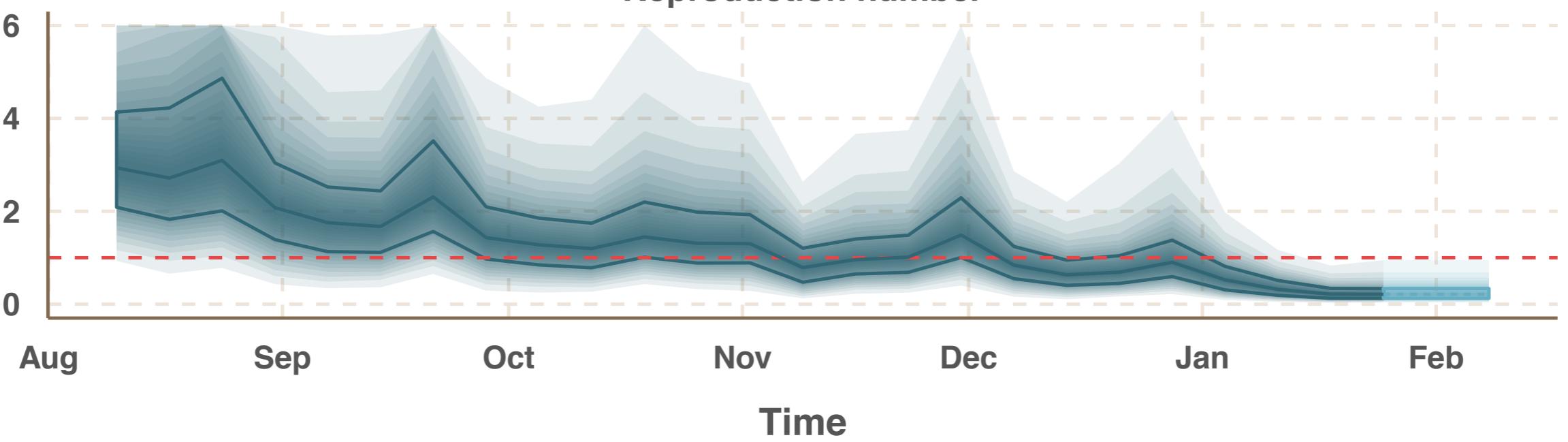
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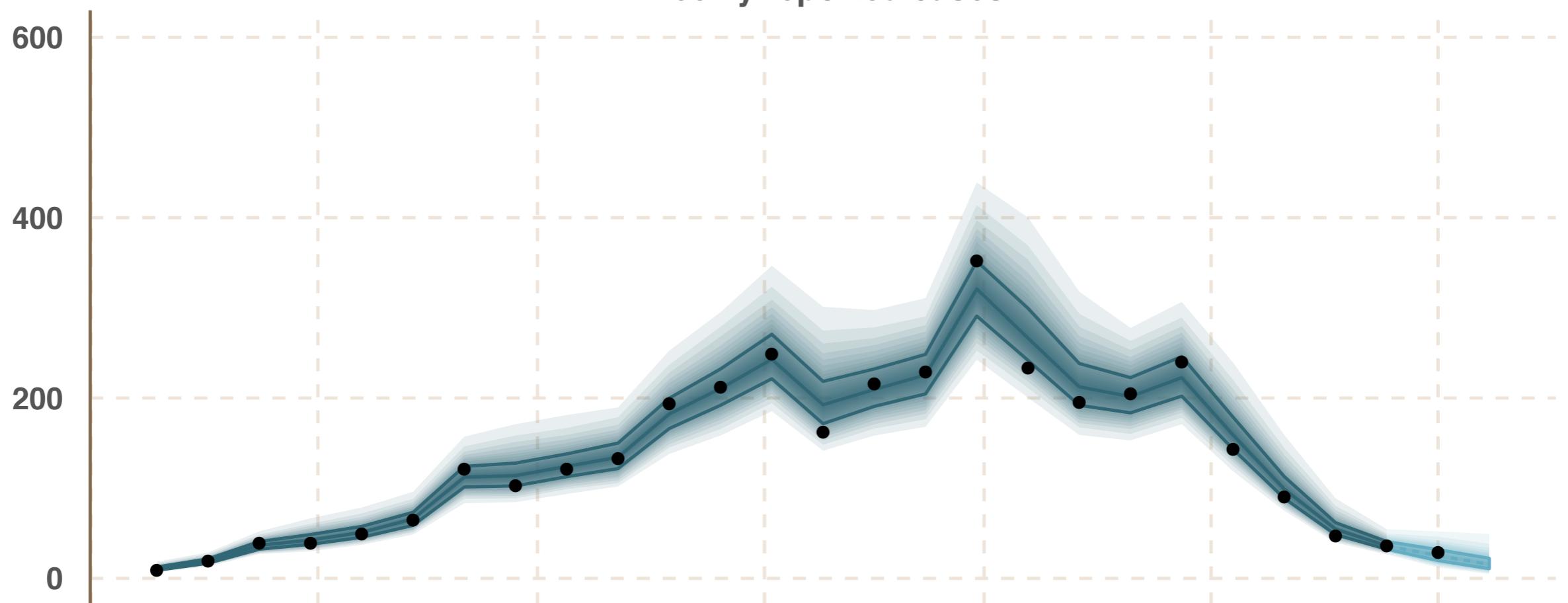
## Weekly reported cases



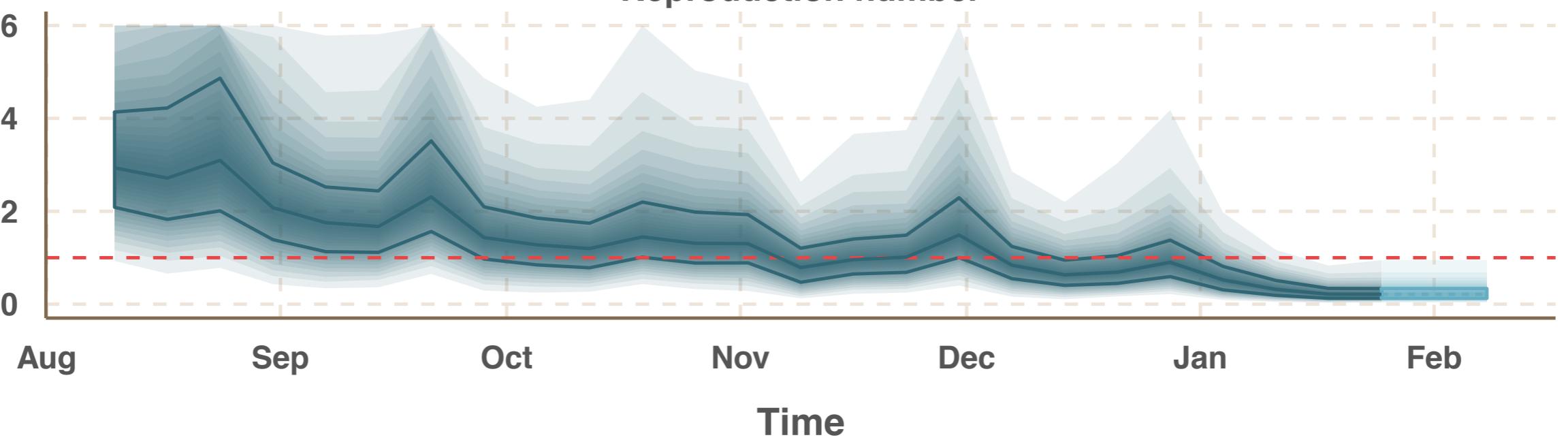
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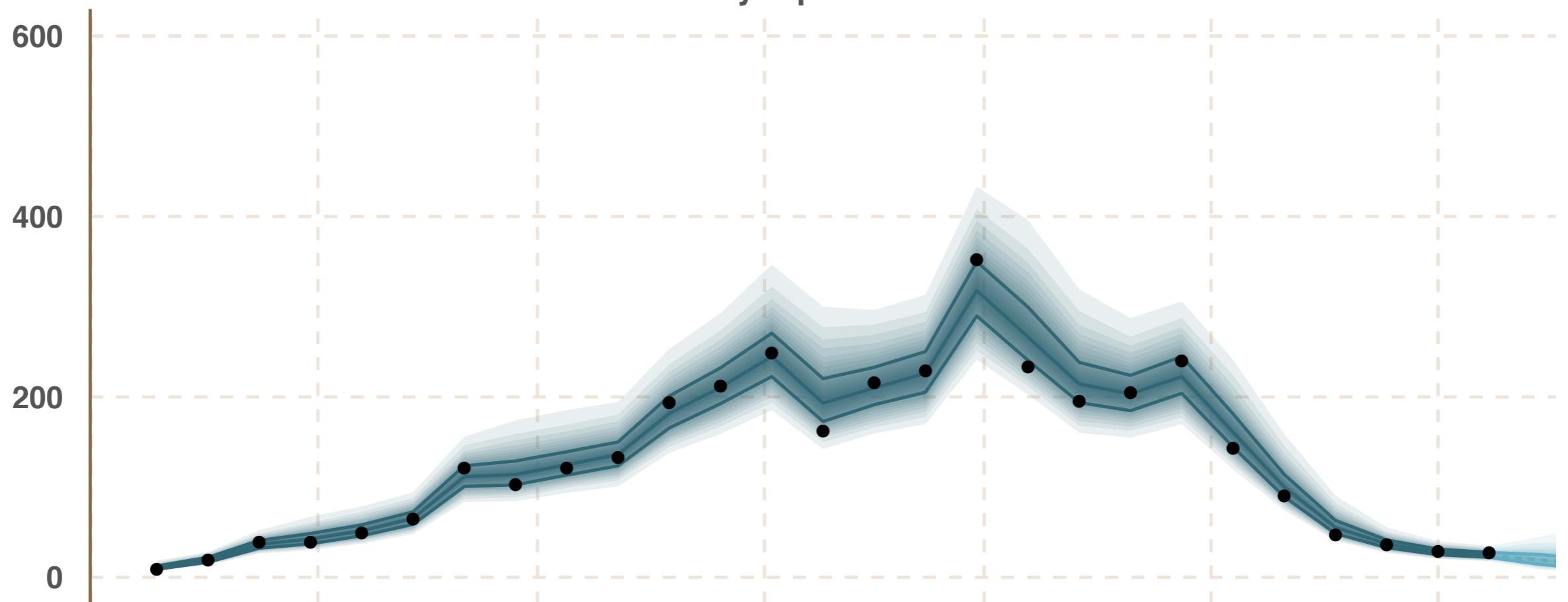
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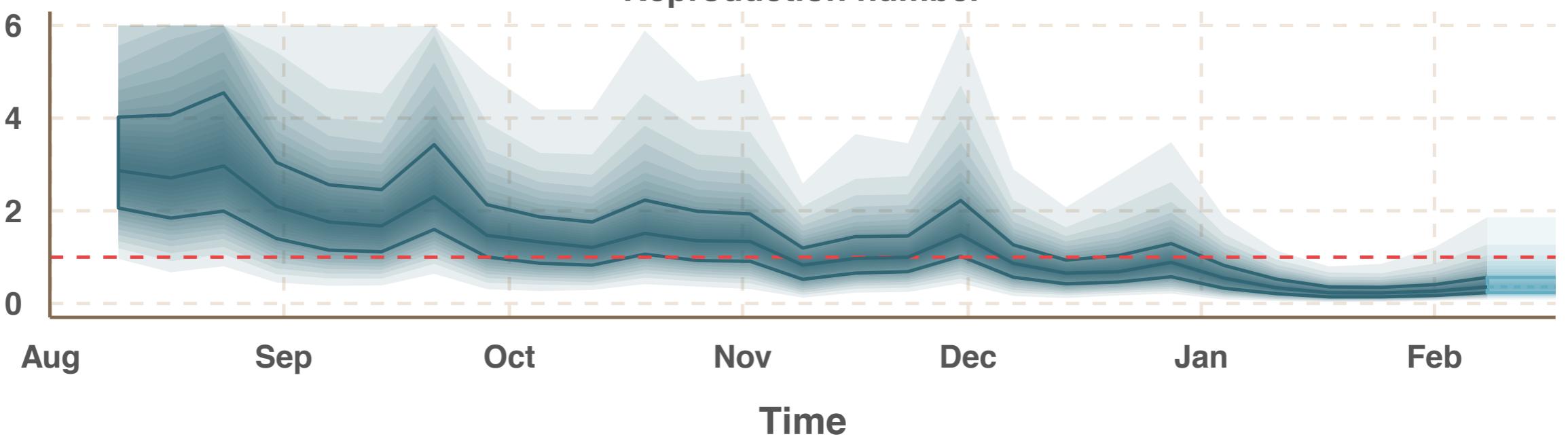
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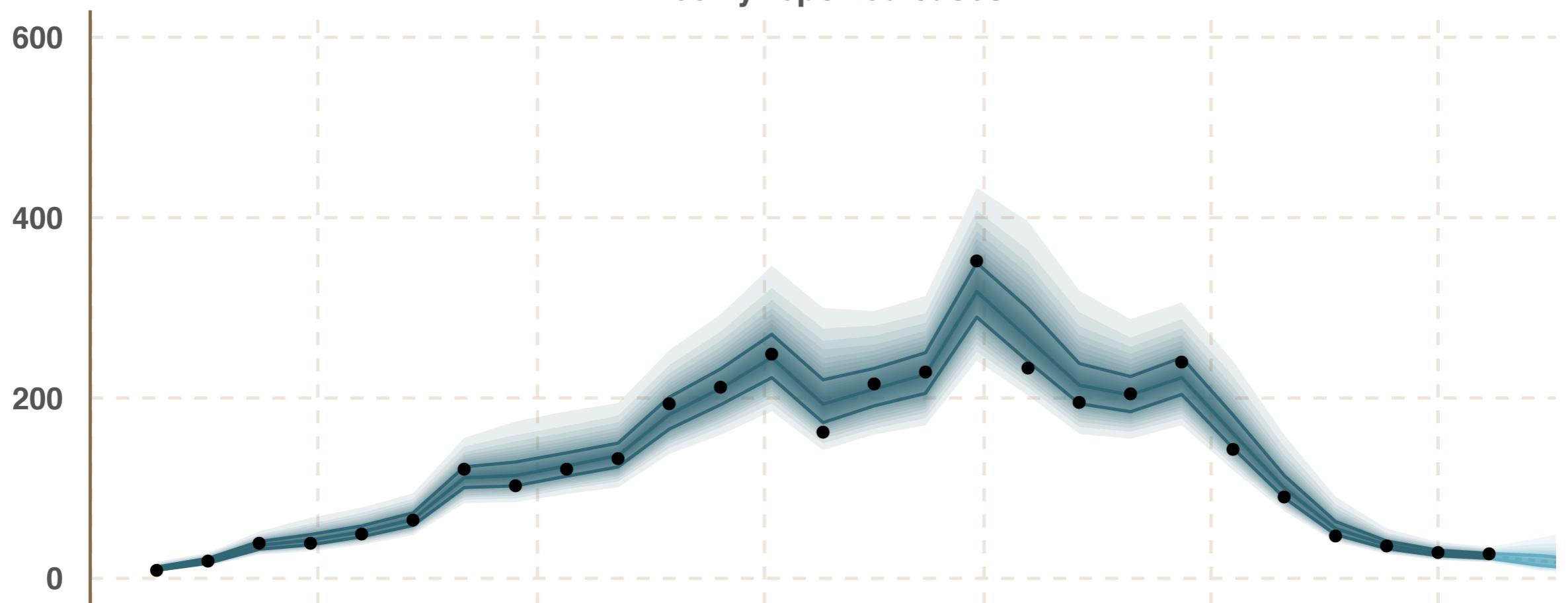
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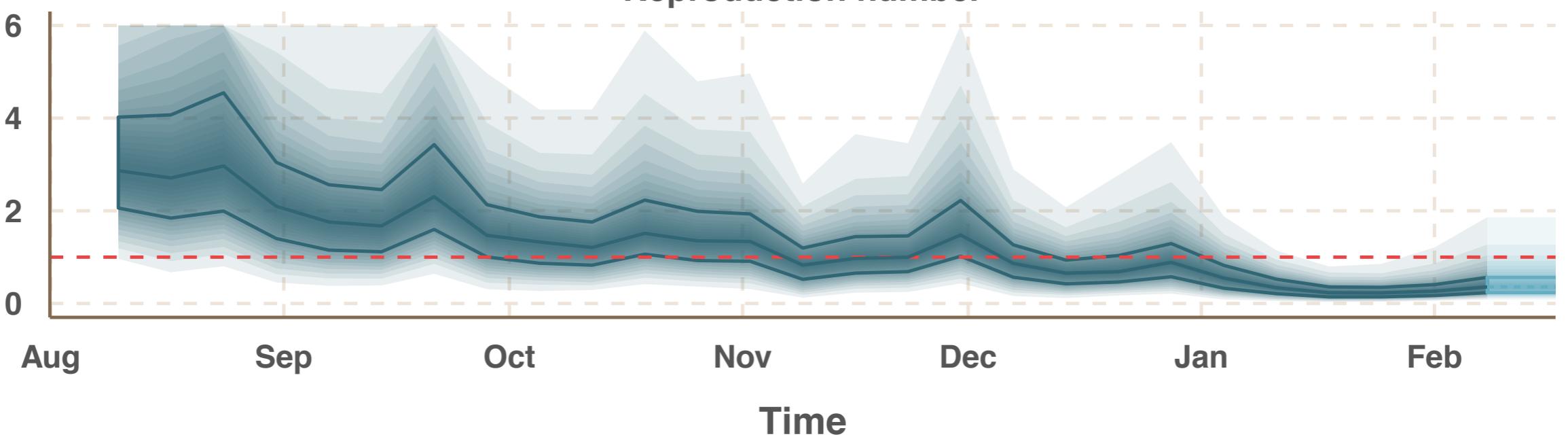
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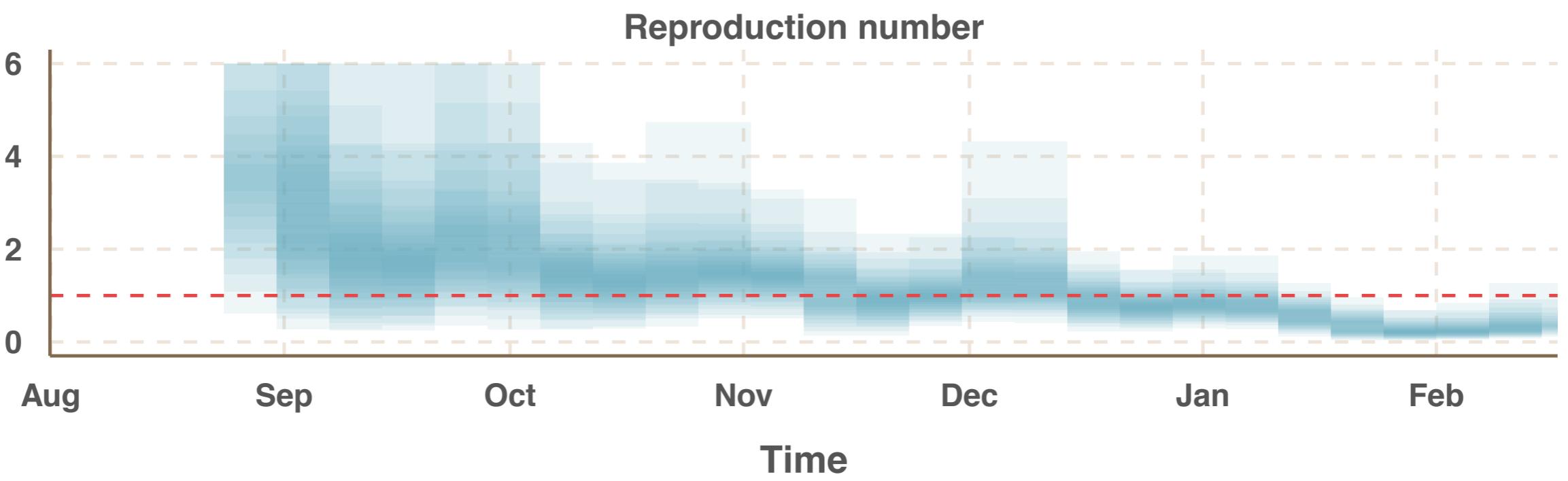
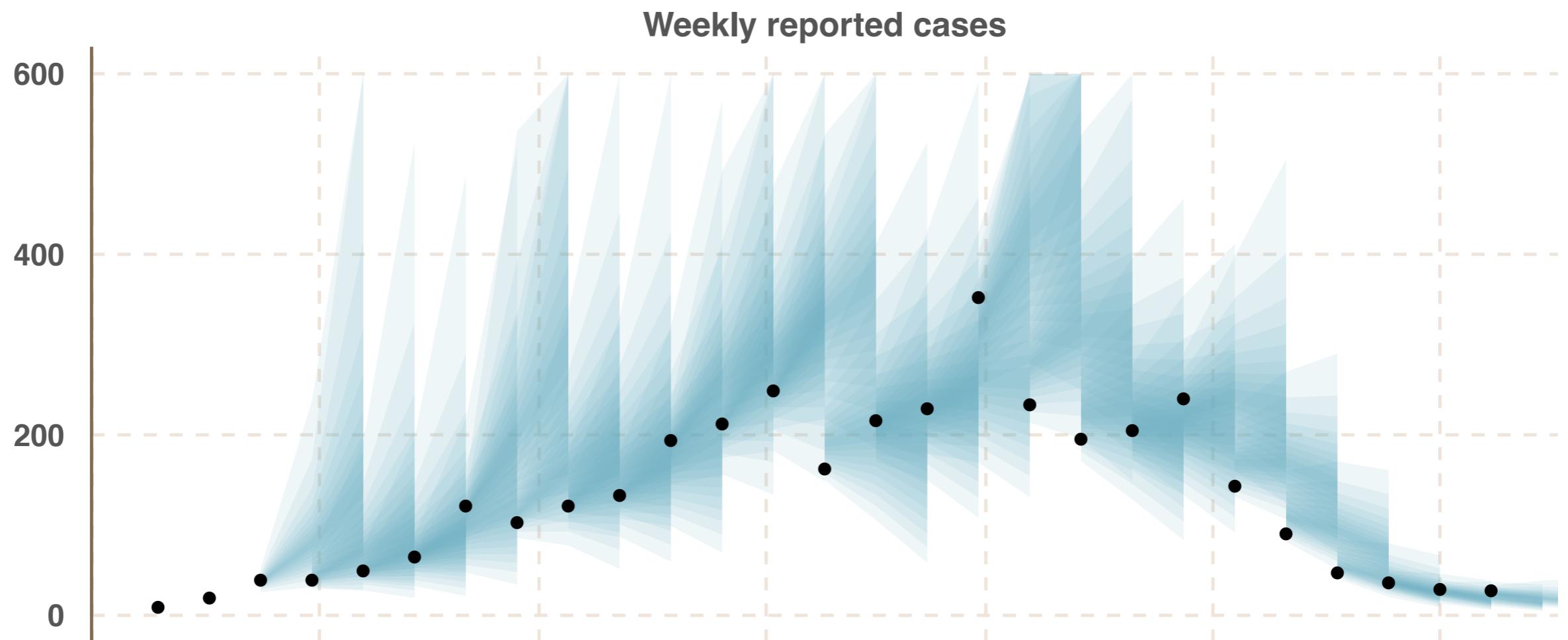


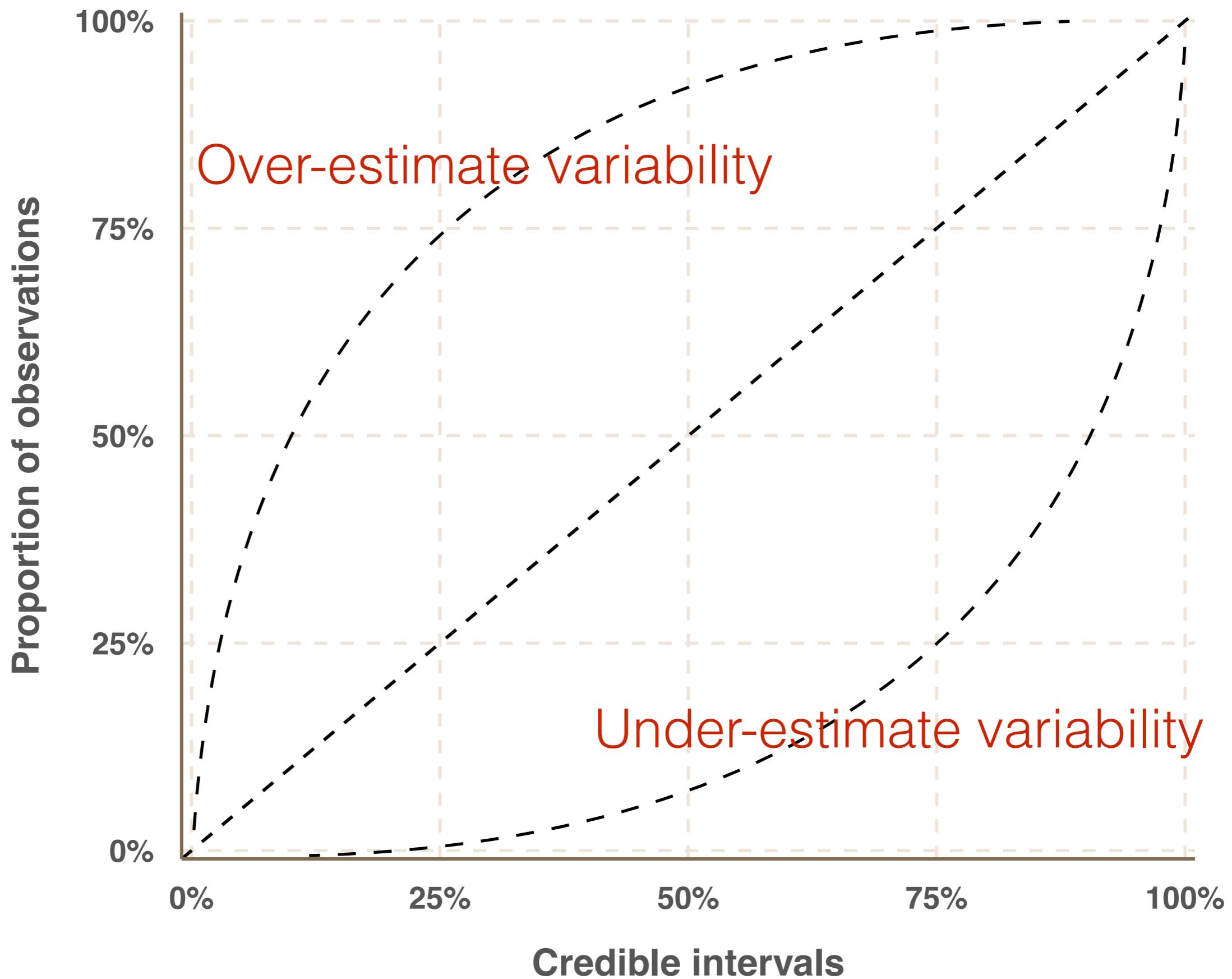
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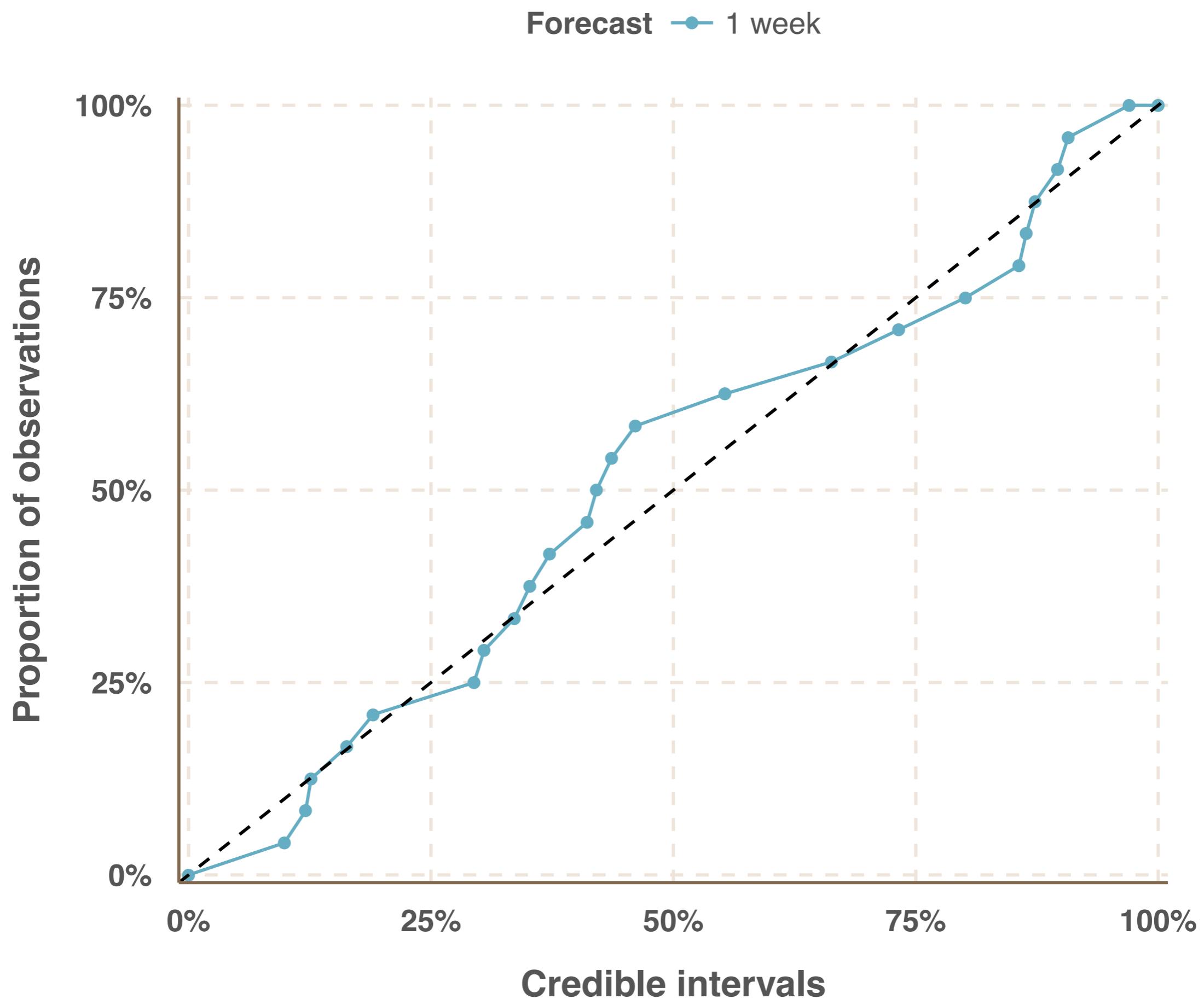


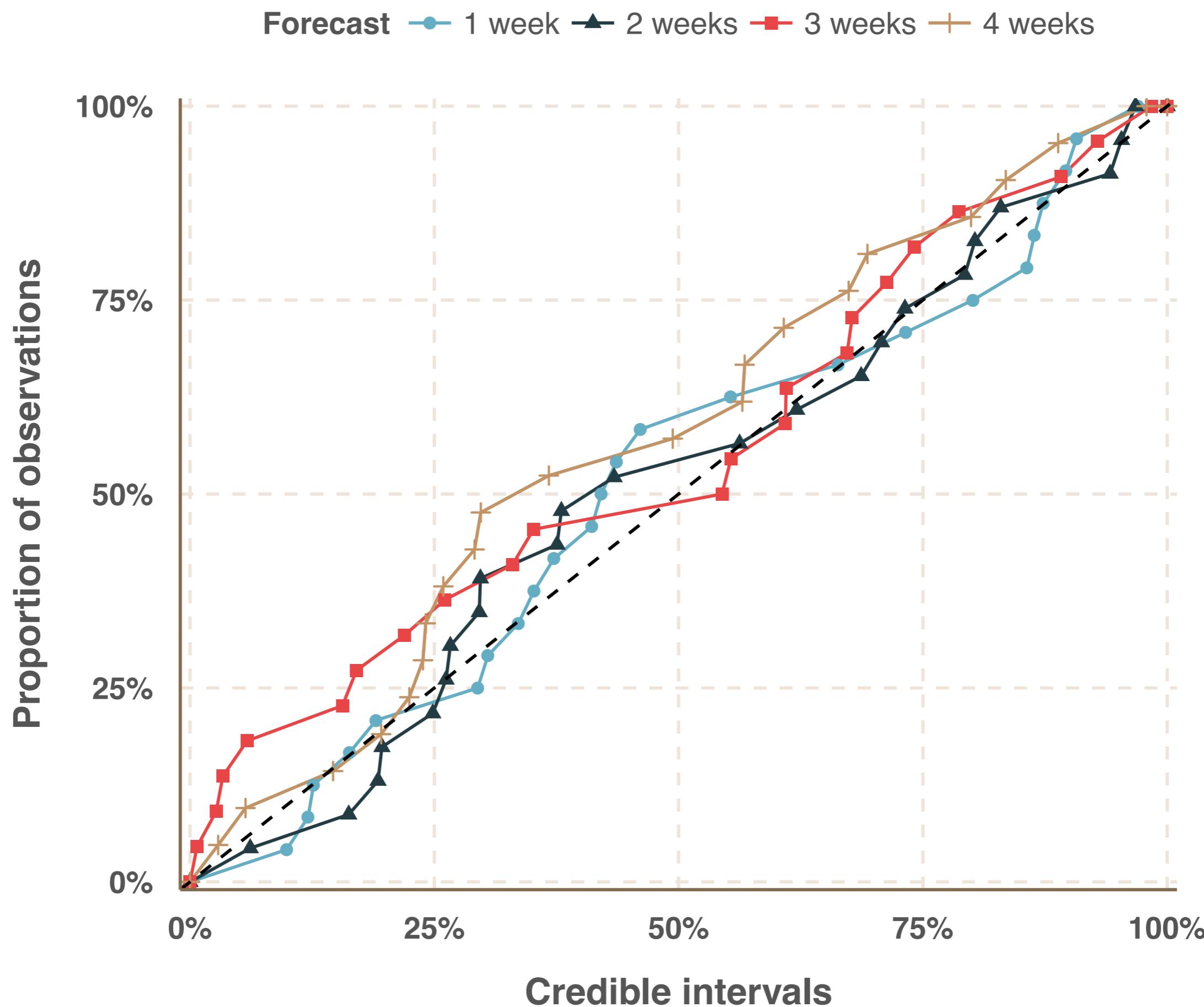
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## EBOLA OUTBREAK IN WEST AFRICA

cmmid members are currently involved in providing real-time modelling of the Ebola outbreak in West Africa, using a range of methods. To better understand the epidemiology of Ebola, we are also investigating previous outbreaks.

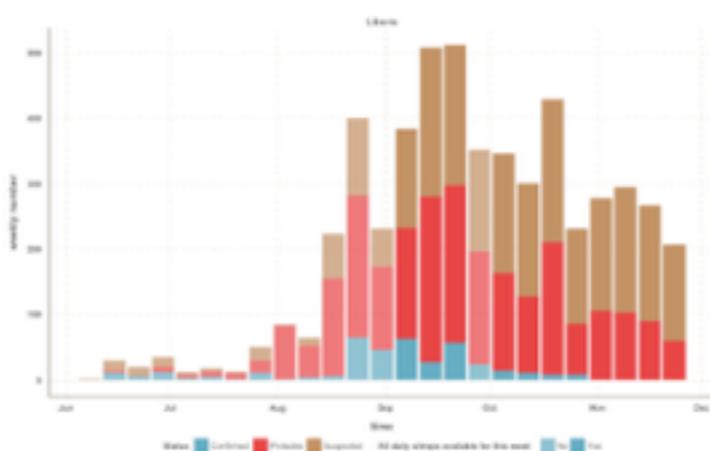
[Situation reports and projections](#)

**People**

[Marc Baguelin](#), [Anton Camacho](#), [John Edmunds](#), [Stefan Flasche](#), [Sebastian Funk](#), [Adam Kucharski](#), [Timothy Pollington](#), [Conall Watson](#)

## CMMID NEWS & EVENTS

- [cmmid@science: review article](#)  
A review article on "[Modeling infectious disease dynamics in the complex landscape of global health](#)" has been published in [Science](#). Several cmmid members have been involved in writing it.
- [cmmid@work: modelling Ebola](#)  
The cmmid has been awarded [funding](#) to continue to help with the modelling for the Ebola response. More details and the latest updates can be found on our [Ebola research](#) page.
- [cmmid@work: journal club](#)  
17 March, 1-2pm Lucas Room (Keppel Street).  
Paper: *Something amazing*. Led by: Andrea



The screenshot shows a web browser window with the URL [ntncmch.github.io](http://ntncmch.github.io) in the address bar. The page title is "Visualisation and projections of the Ebola outbreak in West Africa" by the Centre for the Mathematical Modelling of Infectious Diseases at the London School of Hygiene & Tropical Medicine. Below the title is a bulleted list of links: "Latest weekly reports", "Modelling and projections", "Interactive maps", "Motivation", and "Funding". Under "Latest weekly reports", there are three items: Liberia (up to 15 March 2015), Sierra Leone (up to 15 March 2015), and Guinea (up to 15 March 2015). Each item has a link to an "online version" and a "pdf slides". Under "Modelling and projections", there are three items: Liberia currently does not have any confirmed cases of Ebola, our modelling analysis is provided in a separate report (with links to online version and pdf slides), and we provide a summary of our projections (with links to online version and pdf slides). At the bottom left is a "Display a menu" button.

# Visualisation and projections of the Ebola outbreak in West Africa

by the Centre for the Mathematical Modelling of Infectious Diseases  
London School of Hygiene & Tropical Medicine

- [Latest weekly reports](#)
- [Modelling and projections](#)
- [Interactive maps](#)
- [Motivation](#)
- [Funding](#)

## Latest weekly reports

- Liberia (up to 15 March 2015): view [online version](#) or download [pdf slides](#)
- Sierra Leone (up to 15 March 2015): view [online version](#) or download [pdf slides](#)
- Guinea (up to 15 March 2015): view [online version \(French version\)](#) or download [pdf slides \(French version\)](#)

## Modelling and projections

- Liberia currently does not have any confirmed cases of Ebola, and is therefore no longer included in the modelling and projections.
- Our modelling analysis is provided in a separate report, which also includes a comparison between the SitReps and the WHO linelist data:  
view [online version](#) or download [pdf slides](#)
- We provide a summary of our projections: view [online version](#) or download [pdf slides](#)

## Interactive maps

<http://cmmid.lshtm.ac.uk/research/ebola>

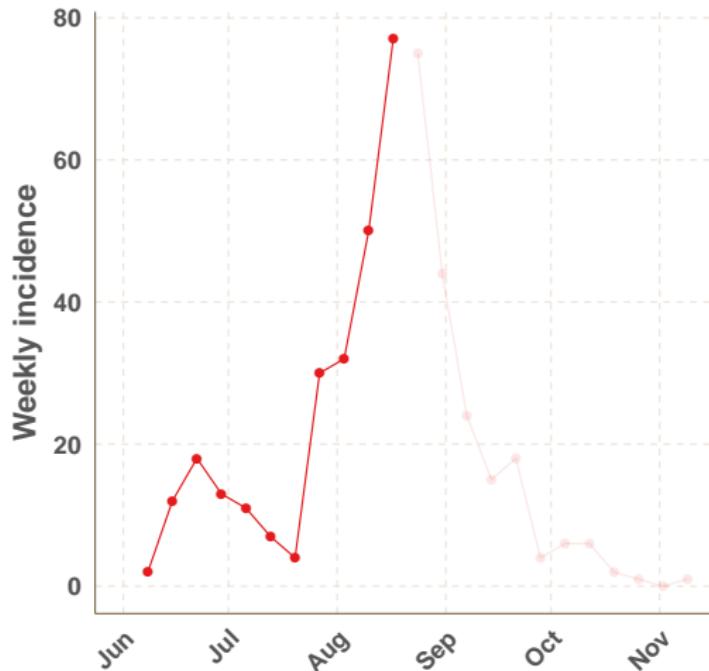




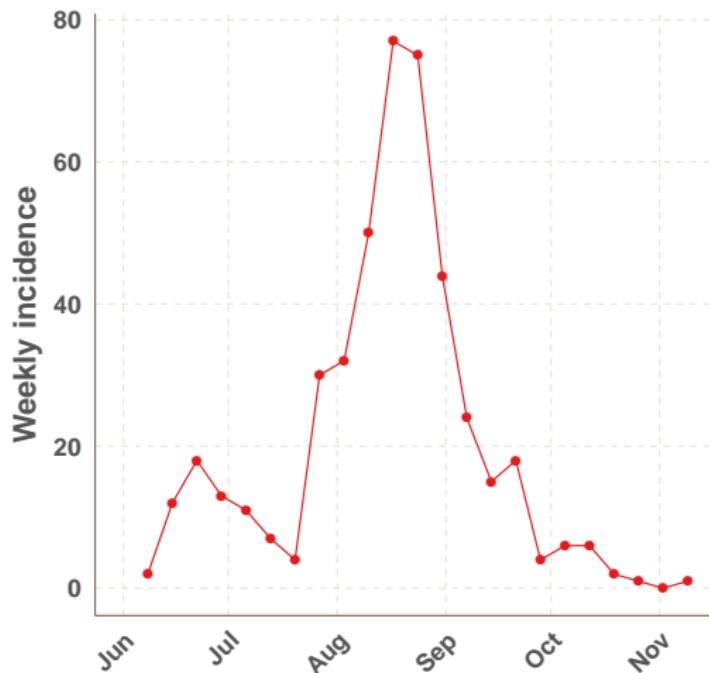
US Dept of State Geographer  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
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# Ebola epidemic in Lofa county, Liberia



# Ebola epidemic in Lofa county, Liberia



What turned the epidemic around?

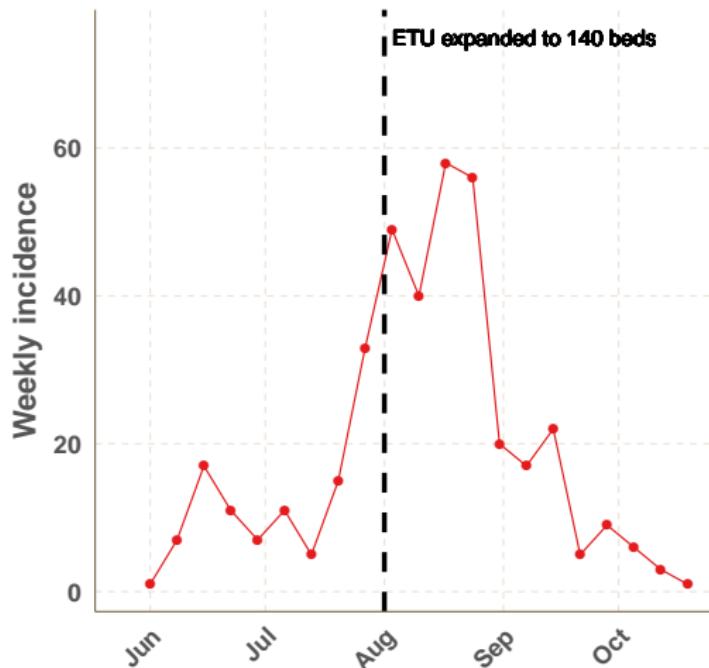
# What turned the epidemic around?

1. Public health response?

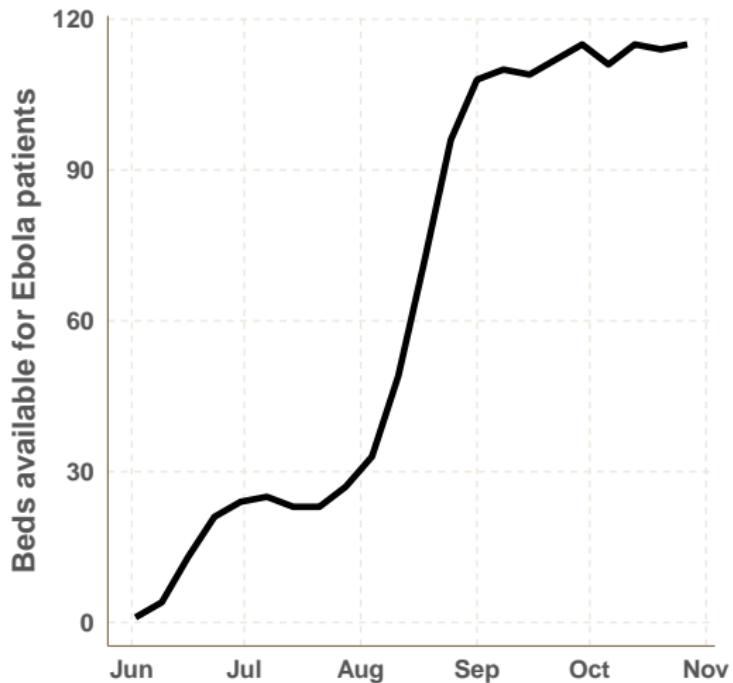




# Ebola epidemic in Lofa county, Liberia



## Expansion of bed capacity



# What turned the epidemic around?

1. Public health response?

## What turned the epidemic around?

1. Public health response?
2. Behavioural changes?



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## Cultural Contexts of Ebola in Northern Uganda

**Barry S. Hewlett\***  and **Richard P. Amolat**

Author affiliations: \*Washington State University, Vancouver, Washington, USA; †Ministry of Health, Adjumani, Uganda

[Suggested citation for this article](#)

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Technical guidelines for the control of Ebola hemorrhagic fever (EHF) indicate that understanding local views and responses to an outbreak is essential. However, few studies with such information exist. Thus, we used qualitative and quantitative methods to determine how local residents of Gulu, Uganda, viewed and responded to the 2000–2001 outbreak of EHF. Results indicated that Acholi people used at least three explanatory models to explain and respond to the outbreak; indigenous epidemic control measures were often implemented and consistent with those being promoted by healthcare workers; and some cultural practices amplified the outbreak (e.g., burial practices). However, most persons were willing to modify and work with national and international healthcare workers.

Many emerging disease specialists are sensitive to and acknowledge the potential

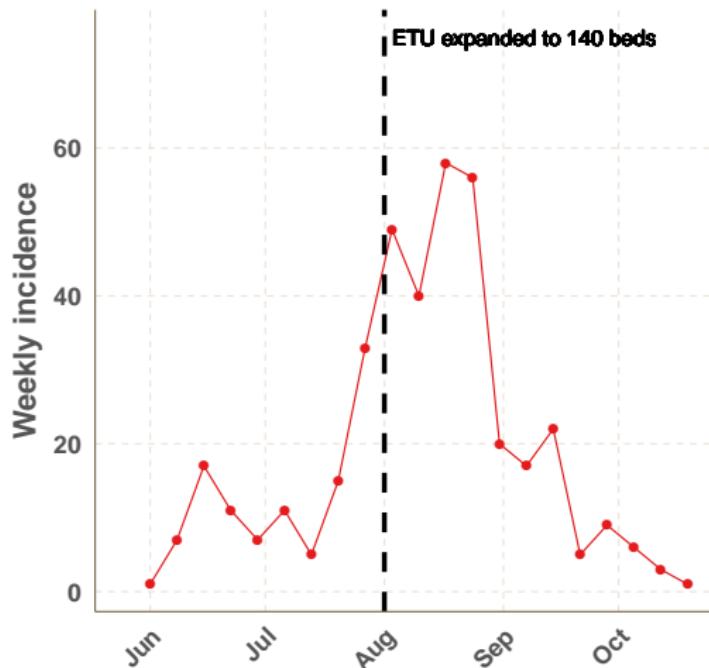
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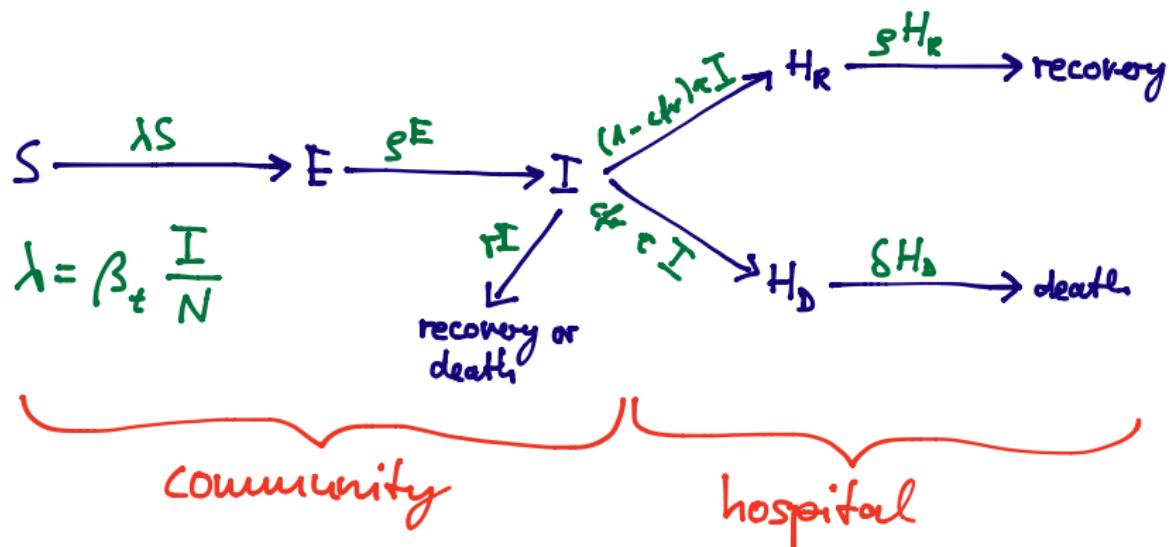
### Tables

[Table 1](#)[Table 2](#)[Table 3](#)[Table 4](#)

# Ebola epidemic in Lofa county, Liberia

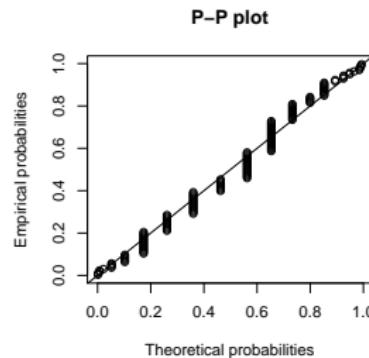
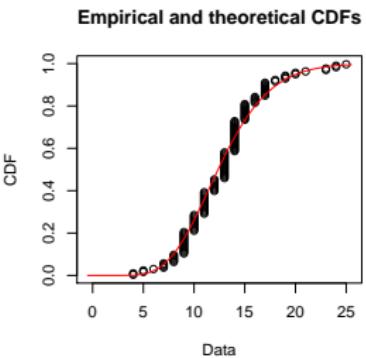
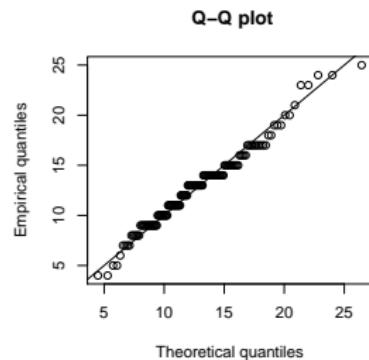
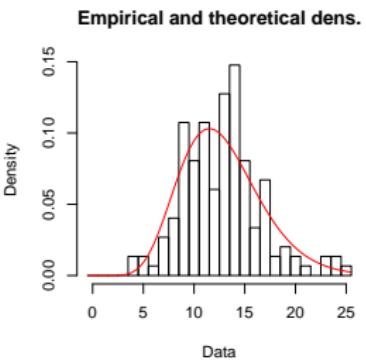


## A model to tease out the different effects



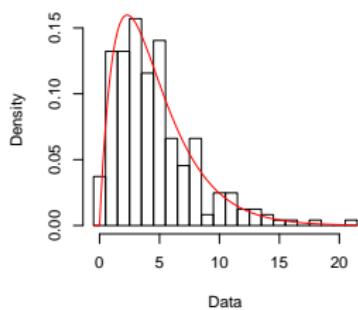
- Bed availability as an **input parameter**
- Ebola cases in hospital **removed** from transmission
- Track **remaining** change in reproduction number R

# Length of stay: recovery

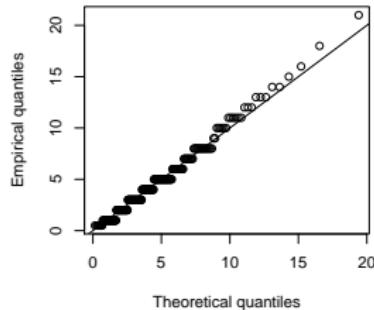


# Length of stay: death

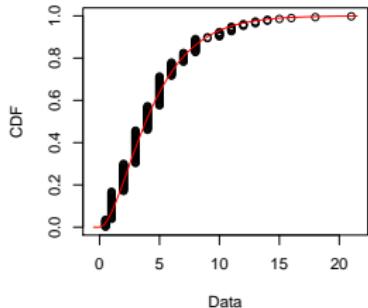
Empirical and theoretical dens.



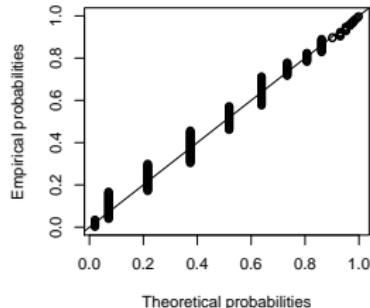
Q-Q plot



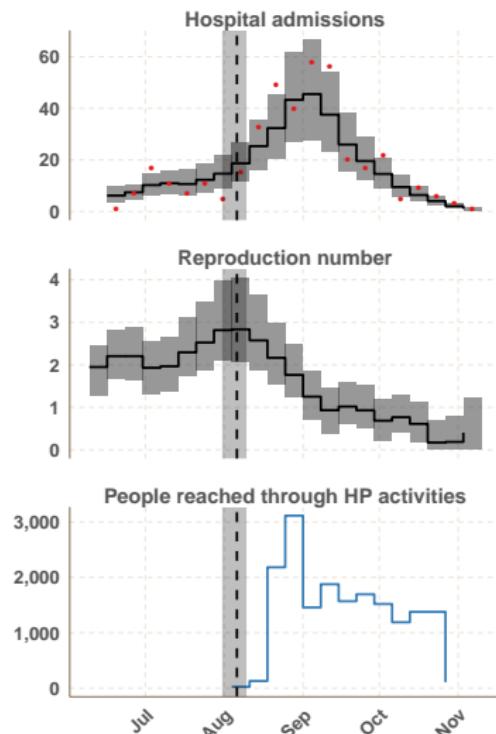
Empirical and theoretical CDFs



P-P plot



# Bed availability vs other factors



## What turned the epidemic around?

1. Public health response?
2. Behavioural changes?

## Summary

- We have used a stochastically fluctuating transmission rate to fit a simple model to the Ebola epidemic.
- With this, we can quantify the variability of the outbreak that the simple model cannot capture.

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- Short-term forecasts.
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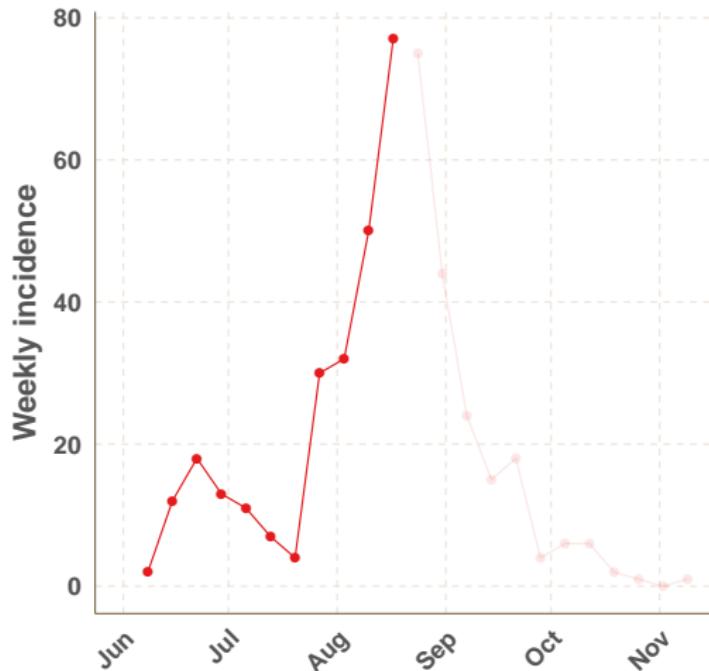
- A. Camacho, et al.  
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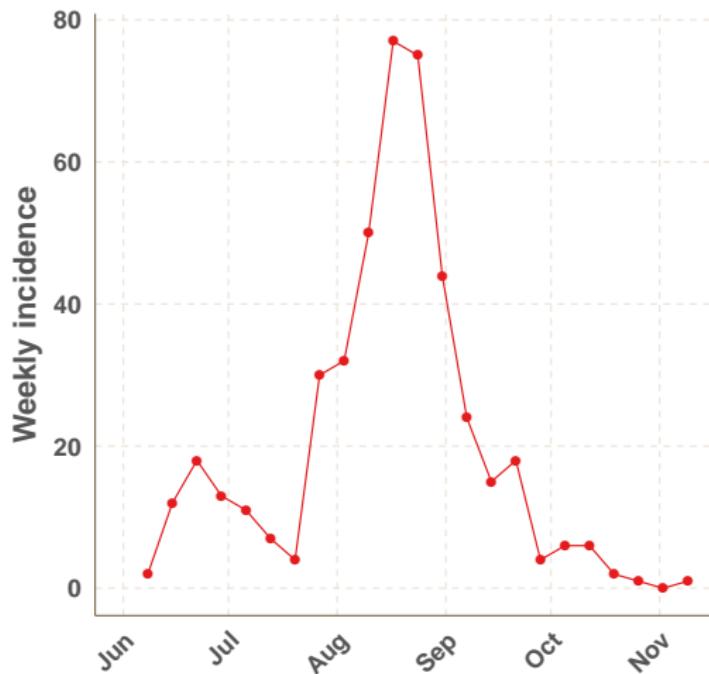
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
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Angola  
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What turned the epidemic around?

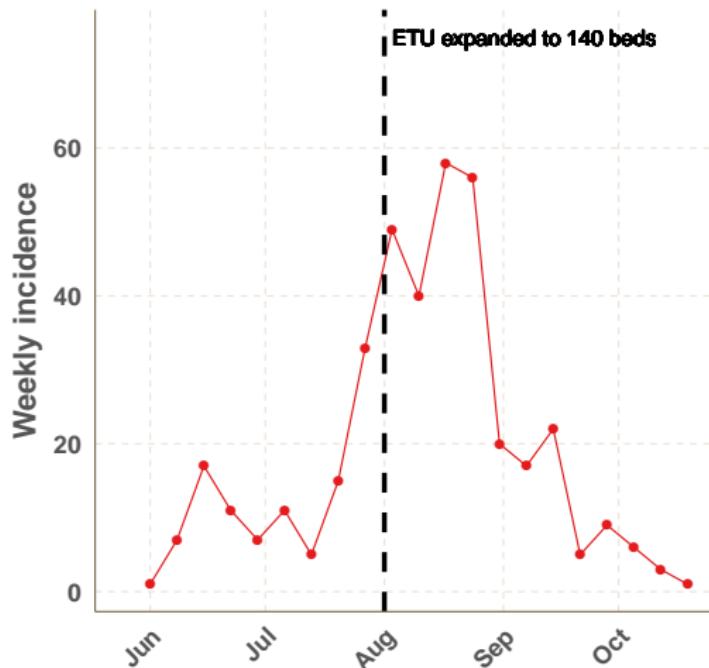
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# Ebola epidemic in Lofa county, Liberia



# What turned the epidemic around?

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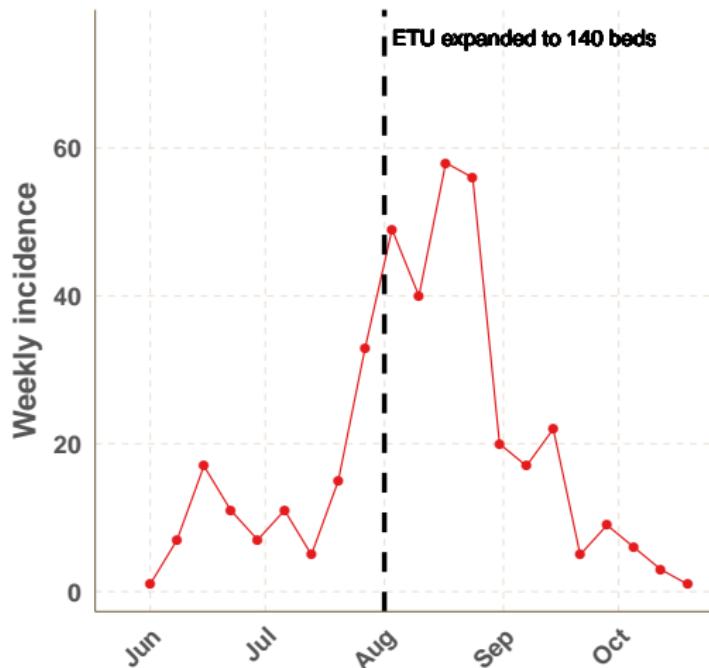
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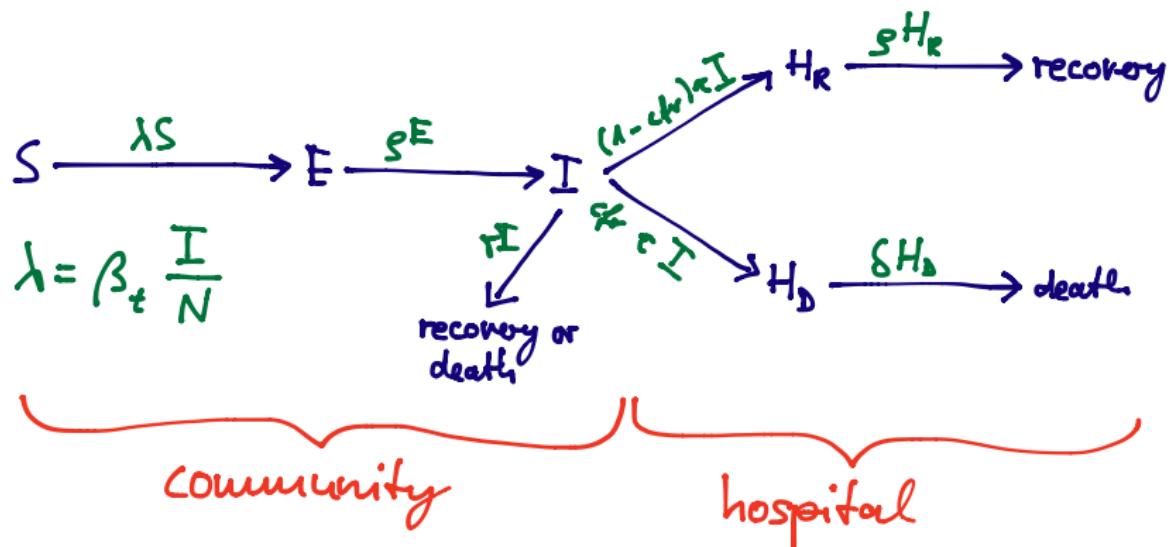
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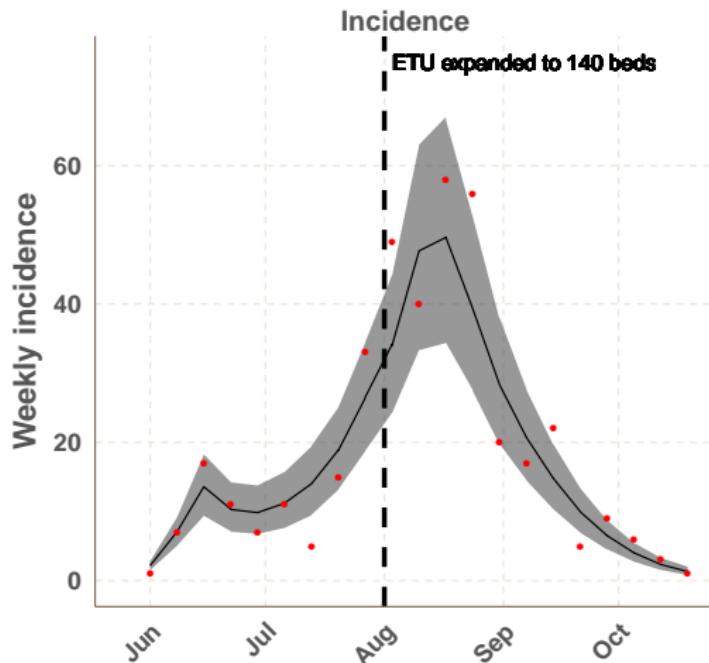


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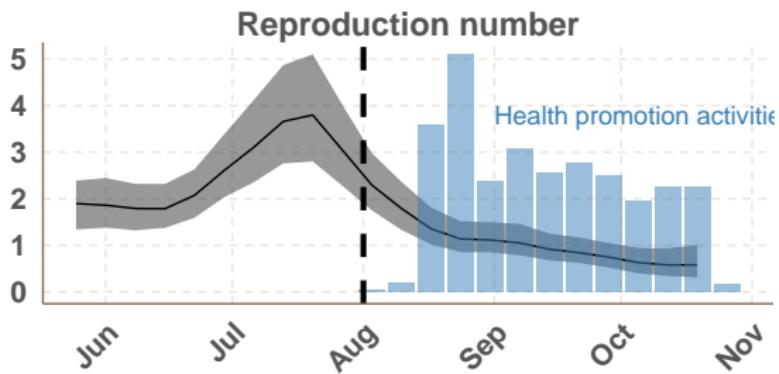
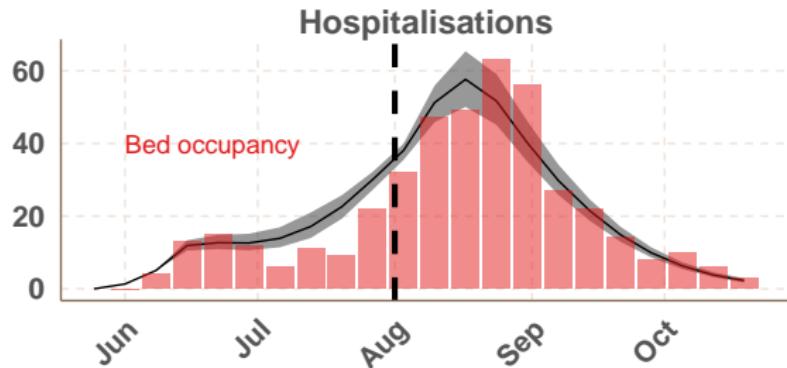


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# Model fit to Ebola epidemic



# Bed availability vs other factors



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