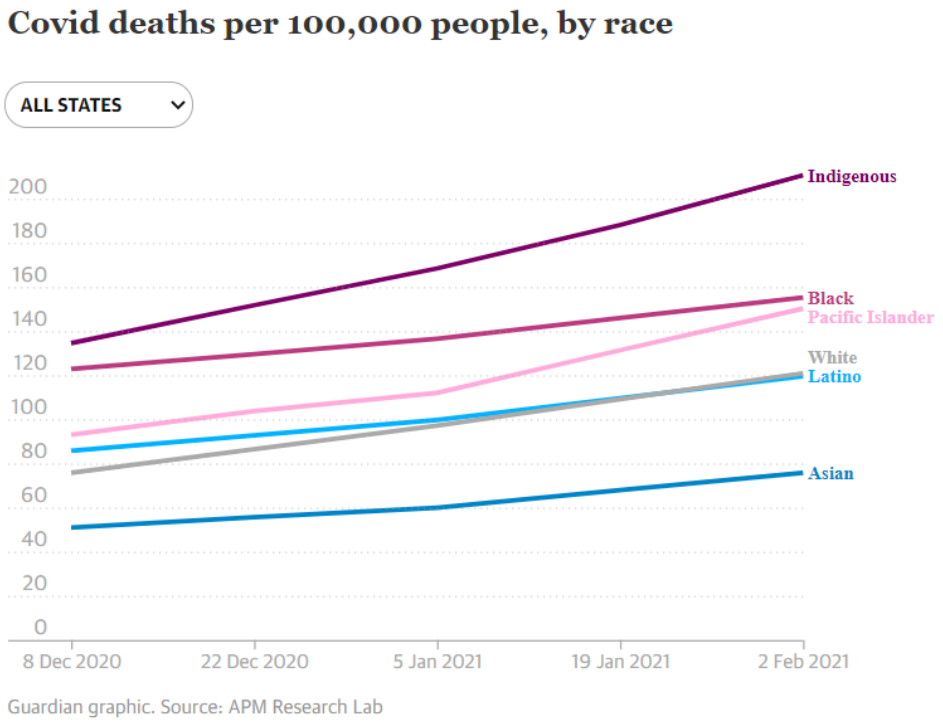
Machine Learning Model to Inform COVID-19 Risk Mitigation Policy

Viktor Glebov*, Gil Gallegos*, Rich Colbaugh†, Kristin Glass†
*New Mexico Highlands University, Las Vegas, New Mexico USA
†Volv Global, Lausanne, Switzerland

Background

- **Indigenous Americans** have been disproportionately hit by COVID-19, experiencing **higher rates of infection**, **hospitalization** and **death** than general population in the US

- Effective risk mitigation should be based upon analysis of the efficacy of social distancing



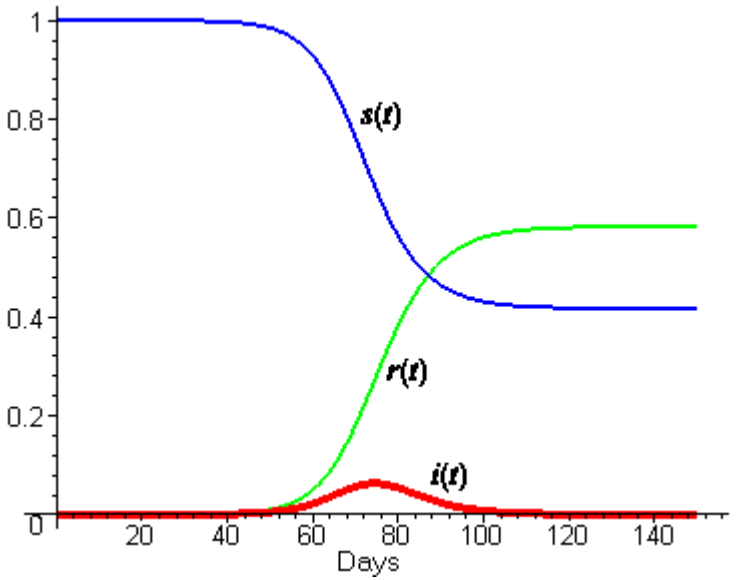
Related work

- Standard models for characterizing/predicting COVID-19 transmission:
  - include susceptible-infectious-removed (SIR) models [e.g. Chen et al. 2020, Weissman et al. 2020] and related models [e.g. Zhou et al. 2020];
  - do not yield consistently-accurate predictions or capture real-world risk mitigation policies, such as masks and social distancing.
- Machine learning (ML) models for characterizing/predicting COVID-19 transmission:
  - adopt traditional data-driven ML approach [Lalmuanawma et al. 2020, Ardabili et al. 2020, Liu et al. 2020, Punn et al. 2020, Chimmula/Zhang 2020];
  - do not leverage medical domain knowledge or nonstandard data sources.

SIR model

- Used for **mathematical modeling of spread** of infectious diseases
- Population is divided into 3 groups: **Susceptible**, **Infectious**, **Recovered**
- **Constant parameters** are used for modeling

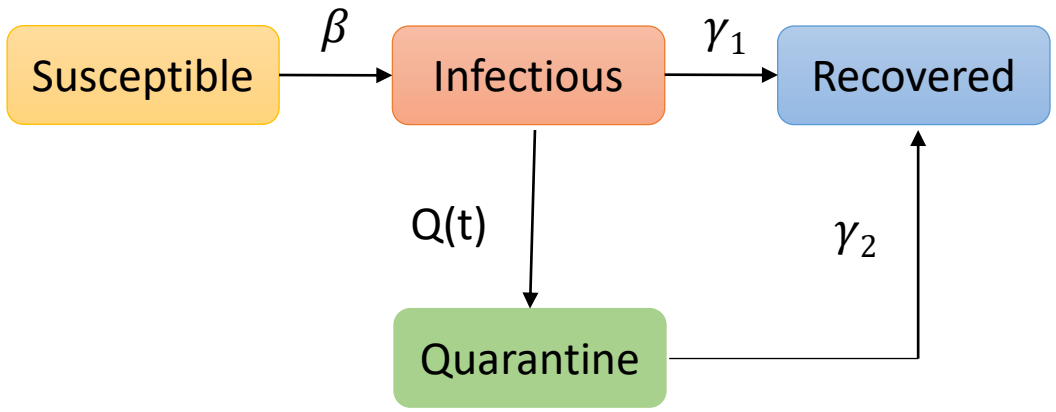
SIR model diagram



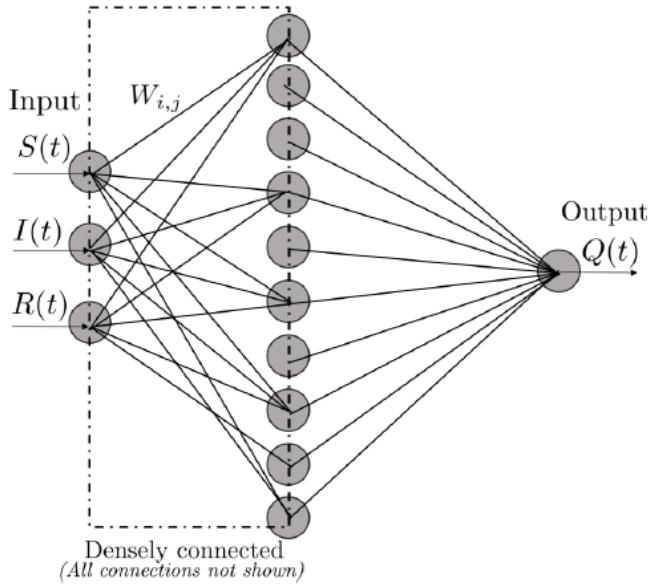
Modeling results

QSIR model

- **introduce quarantining/social distancing** into the SIR model as a function Q(t)
- **use** the resulting **Q as a metric** for public adherence to, and utility of, disease-containment policy



SIR-Q model diagram



ML model for Q(t)

Source: Dandekar, R., Rackauckas, C., & Barbastathis, G. (2020). A Machine Learning-Aided Global Diagnostic and Comparative Tool to Assess Effect of Quarantine Control in COVID-19 Spread. Patterns, 1(9), 100145.

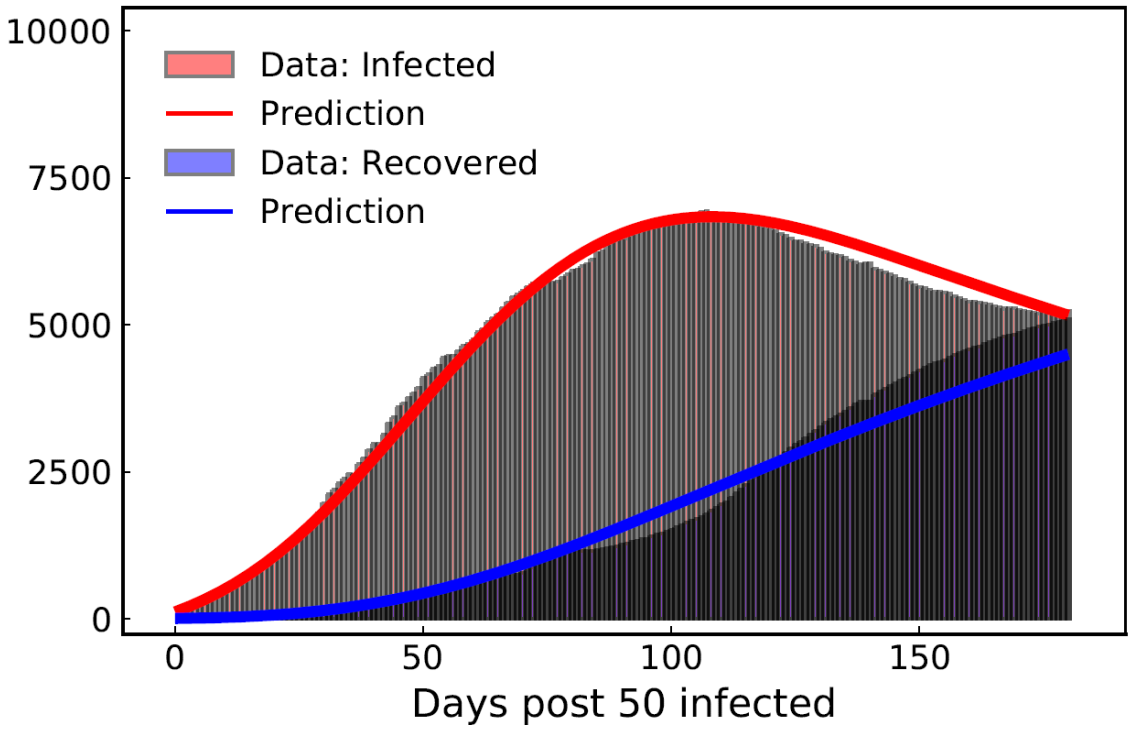
Setup

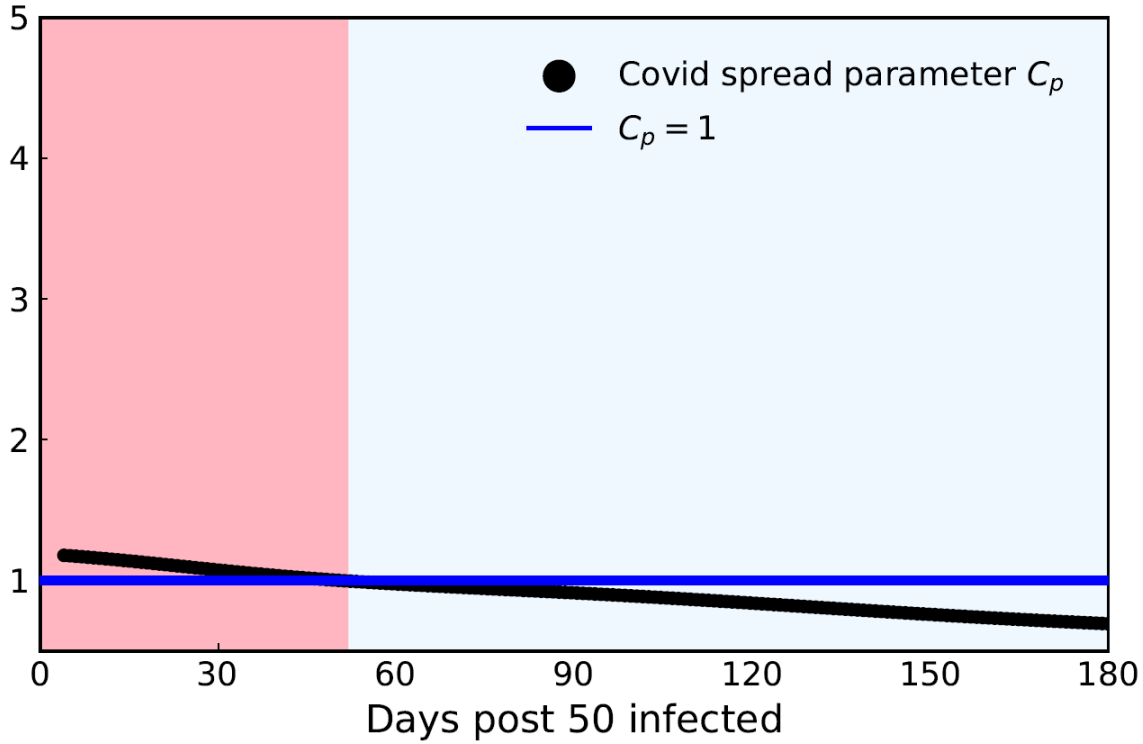
- Objective – investigate the feasibility of use of machine learning models to inform COVID-19 policy for Navajo Nation
- Tasks
  - modify and apply QSIR model to real COVID-19 data for Navajo Nation
  - estimate quarantine function Q(t)
  - compare results to the real data

Data sources

- COVID-19 infection and policy data:
  - Navajo Times https://navajotimes.com/coronavirus-updates/covid-19-across-the-navajo-nation/
  - Navajo Nation COVID-19 Dashboard https://www.ndoh.navajo-nsn.gov/COVID-19/Data
- Mobility data
  - Apple Mobility Trends https://covid19.apple.com/mobility
  - Google Mobility Trends https://www.google.com/covid19/mobility/

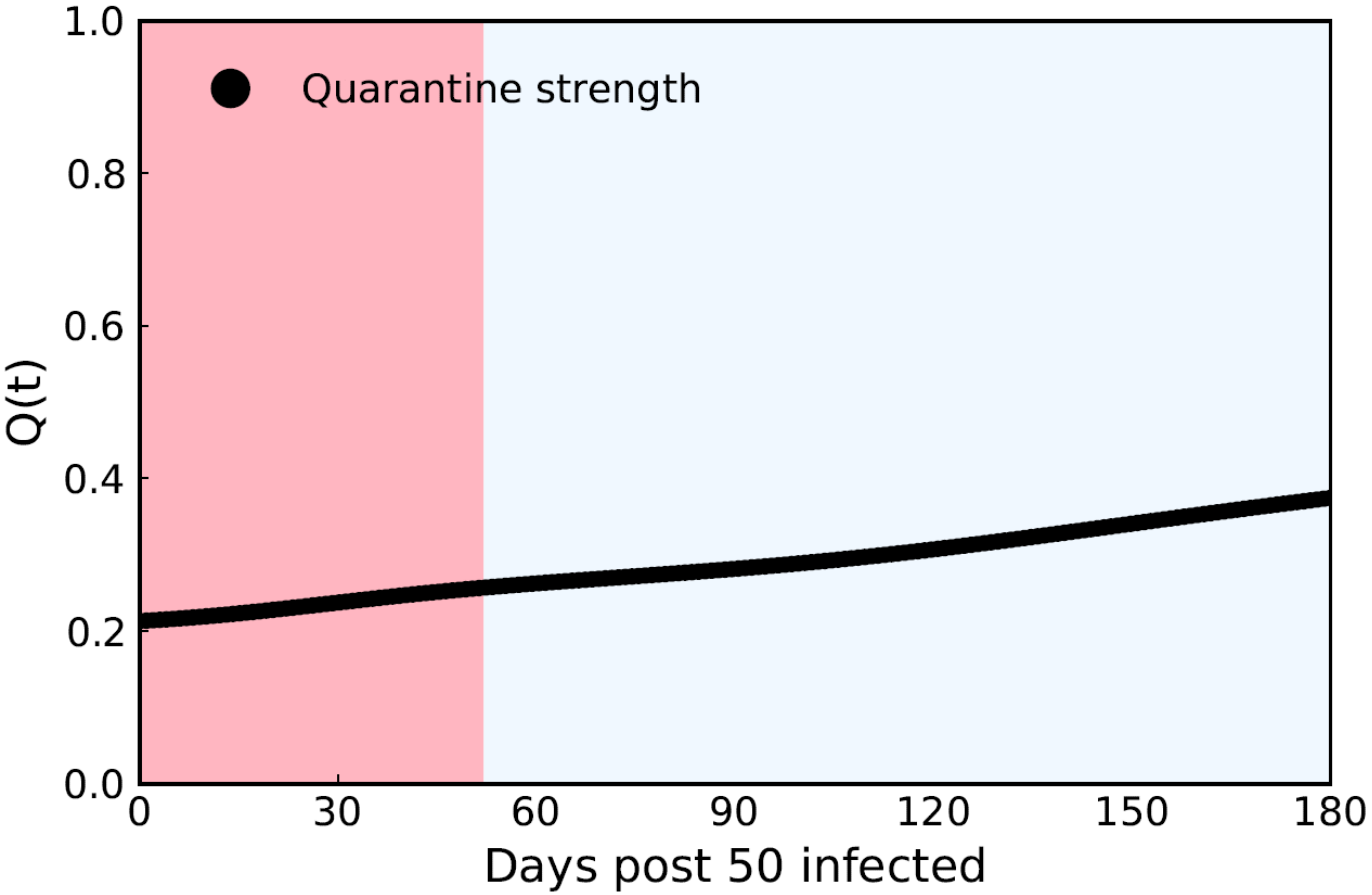
QSIR model



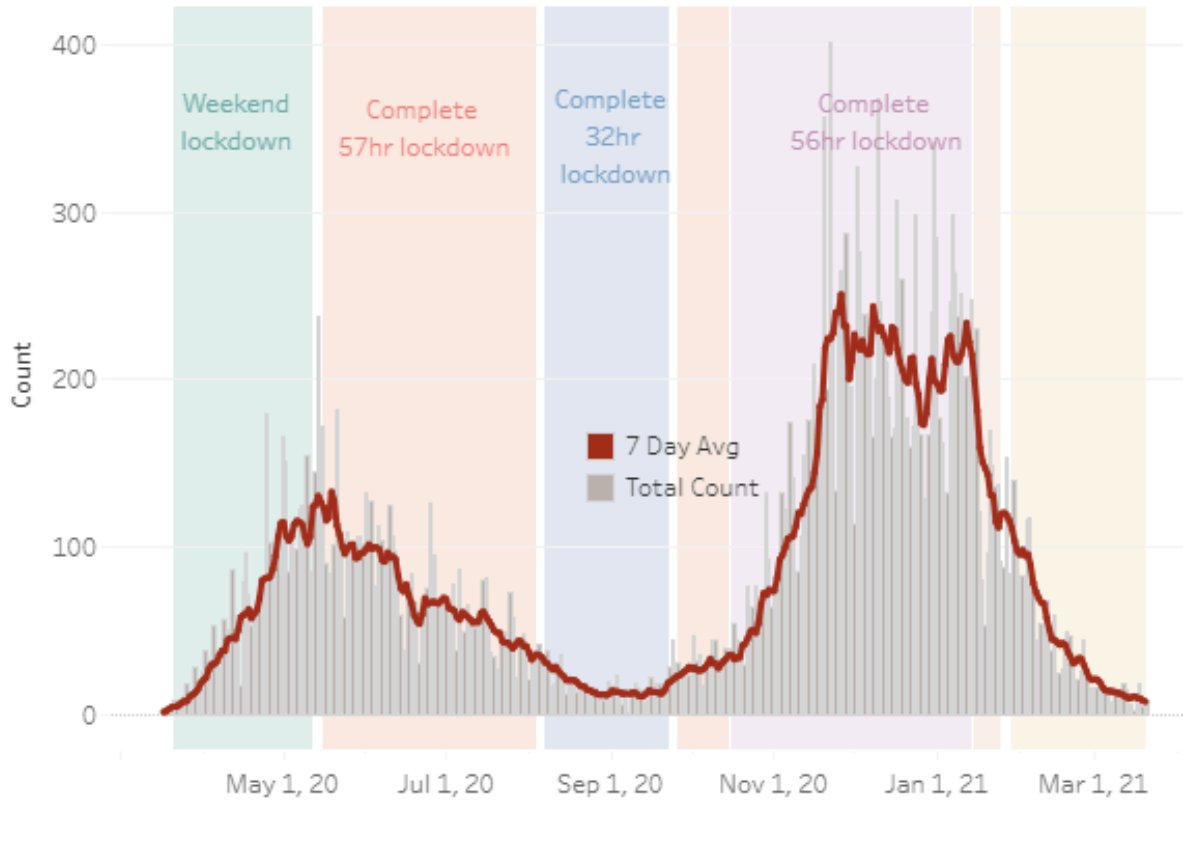


Results of modeling for the 1st wave of COVID-19 on the Navajo Nation

QSIR model validation

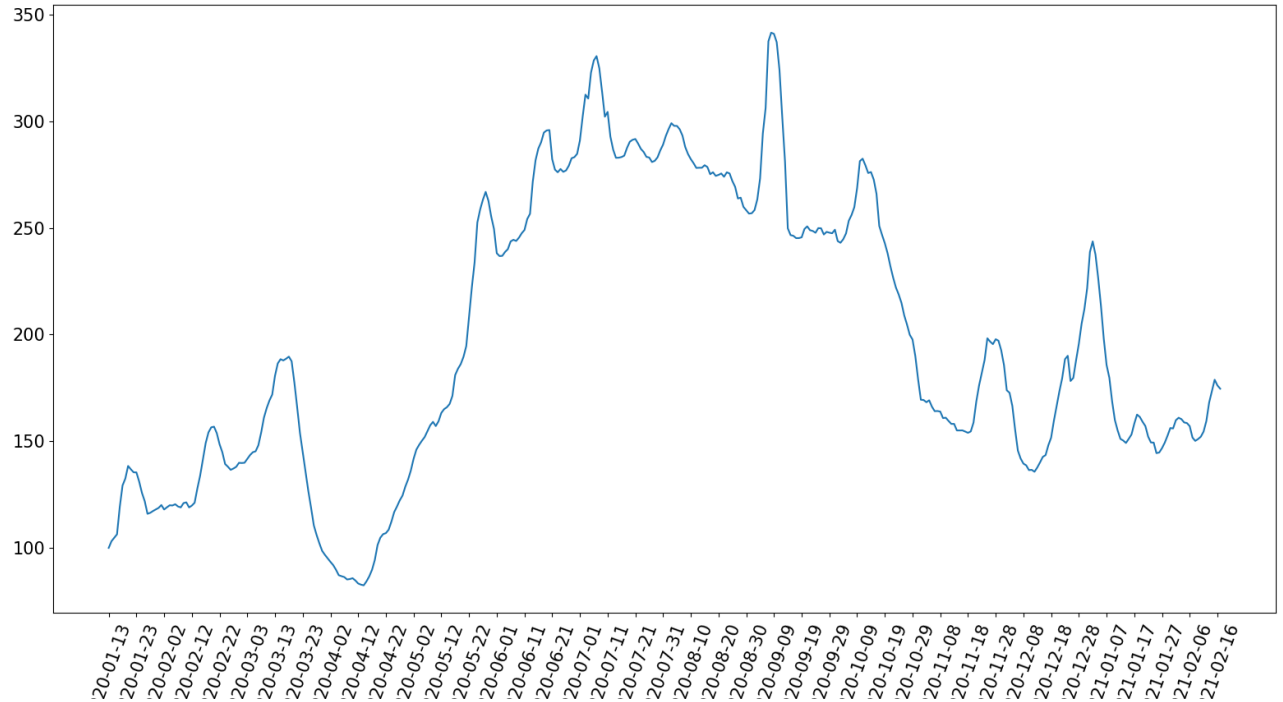


Predicted quarantine strength (1st wave)
Day 0 – April 17th



Real case count and policy
Source: Navajo Nation Department of Health

Mobility trends



Mobility trends for Navajo county

Conclusions

- Machine learning methods can improve accuracy of classical epidemiological models
- QSIR model offers potential for near real-time monitoring of generalized quarantine efficiency, a metric likely to be useful for informing/adjusting epidemic containment strategies
- There are many ways to improve/extend existing models

References

- Dandekar, R., Rackauckas, C., & Barbastathis, G. (2020). A Machine Learning-Aided Global Diagnostic and Comparative Tool to Assess Effect of Quarantine Control in COVID-19 Spread. Patterns, 1(9), 100145.
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Thank you for your attention!