Quantifying the Effects of COVID-19 on Restaurant Reviews

Ivy Cao, **Zizhou (Gary) Liu**, Giannis Karamanolakis, Daniel Hsu, Luis Gravano

Columbia University, New York, NY 10027, USA

{ic2502, zl2889}@columbia.edu, {gkaraman, djhsu, gravano}@cs.columbia.edu

Outline

- COVID-19 and Restaurants
- New Dataset: Aspect-Annotated Yelp Reviews
- Experiments: COVID-19 Aspect Extraction
- Experiments: Time Series Analysis
- Conclusion

Outline

- COVID-19 and Restaurants
- New Dataset: Aspect-Annotated Yelp Reviews
- Experiments: COVID-19 Aspect Extraction
- Experiments: Time Series Analysis
- Conclusion

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Have restaurant reviews changed during the pandemic?

The pandemic may have affected **customer preferences**

- changes in preferred **cuisine** types
- higher expectations of **hygiene** practices
- higher expectations of **social distance** practices

Example of Yelp restaurant reviews discussing **hygiene** practices:

⭐☆☆☆☆ March 3rd, 2020

I usually go there for my pizza but I had to walk out because I saw the employees handling the food with no **gloves** on. In light of the recent outbreak of the **Coronavirus** how are they still not wearing **gloves**?

This Paper

We analyze 3 million Yelp reviews published before and after the pandemic for restaurants in NYC and LA County (two largest metropolitan areas)

Our Contributions

1. Create a dataset with fine-grained COVID-19 annotations
2. Evaluate COVID-19 aspect extraction techniques
3. Analyze Yelp reviews and critical COVID-19 statistics over time

Provides insights for restaurant owners, customers, public health officials and broader research community!

Paper and dataset available at https://publichealth.cs.columbia.edu

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Outline

- COVID-19 and Restaurants
- **New Dataset: Aspect-Annotated Yelp Reviews**
- Experiments: COVID-19 Aspect Extraction
- Experiments: Time Series Analysis
- Conclusion

Yelp Data Collection and Annotation

- 3 million Yelp reviews of restaurants[1]
- New York City (NYC) & Los Angeles County (LA)
- Time period: Jan 1st 2019 - Dec 31st 2020

1. Data: collaboration with Yelp and health departments in NYC and LA County
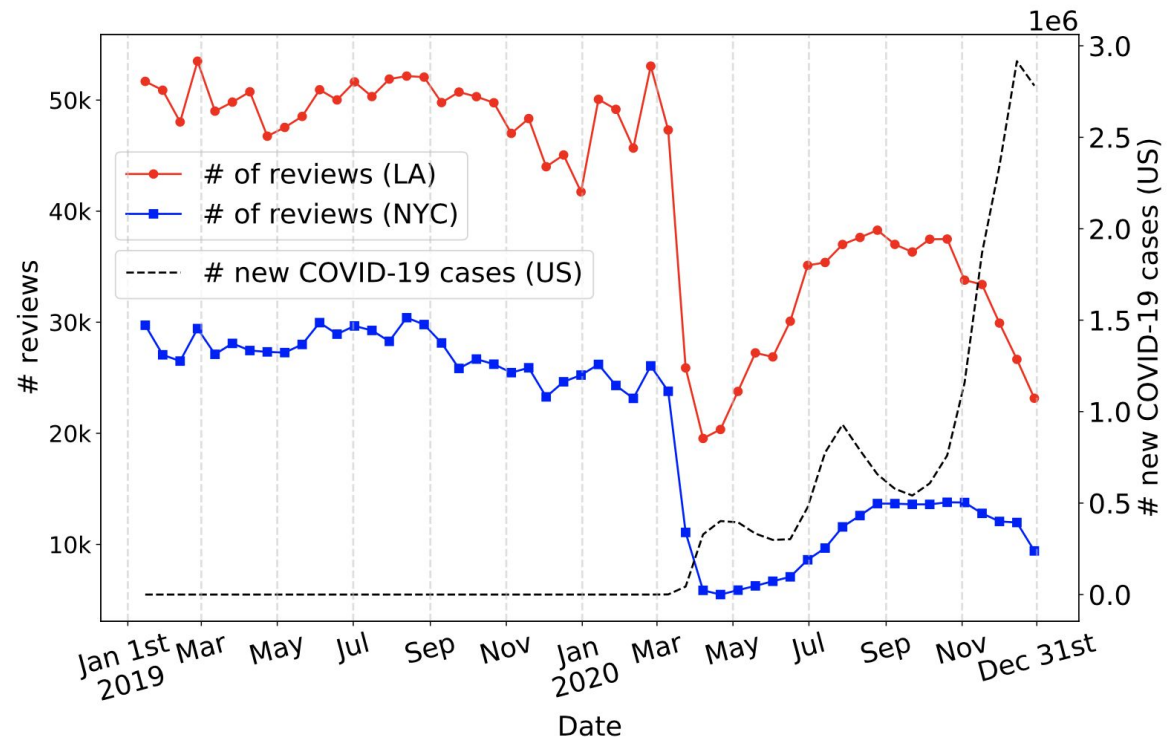
Yelp Data Collection and Annotation

- Create a dataset of 600 Yelp restaurant reviews
- Manually annotation with 7 COVID-19 aspects

  {Hygiene, Transmission, Social Distancing, Racism, Sympathy & Support, Services, Other}

★★★☆☆ July 30th, 2020

… Just know there's no restroom or sink for patrons to wash their hands. They do have hand **sanitizers** and **wipes**, but personally I prefer washing my hands …

Hygiene

Outline

- COVID-19 and Restaurants
- New Dataset: Aspect-Annotated Yelp Reviews
- Experiments: COVID-19 Aspect Extraction
- Experiments: Time Series Analysis
- Conclusion

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

COVID-19 Aspect Detection

Task: Classify review text into COVID-19 aspects

Fully Supervised approach: Leverage manually labeled data
Weakly-Supervised approach: Leverage aspect-specific keywords

COVID-19 Aspect Detection

Task: Classify review text into COVID-19 aspects

Fully Supervised approach: Leverage manually labeled data

- Bag-of-words Support Vector Machine (BoW-SVM)：
  Represents each review as a bag of unigrams/bigrams
  Classifies review using SVM

- BERT:
  Represents each review using a pre-trained transformer model
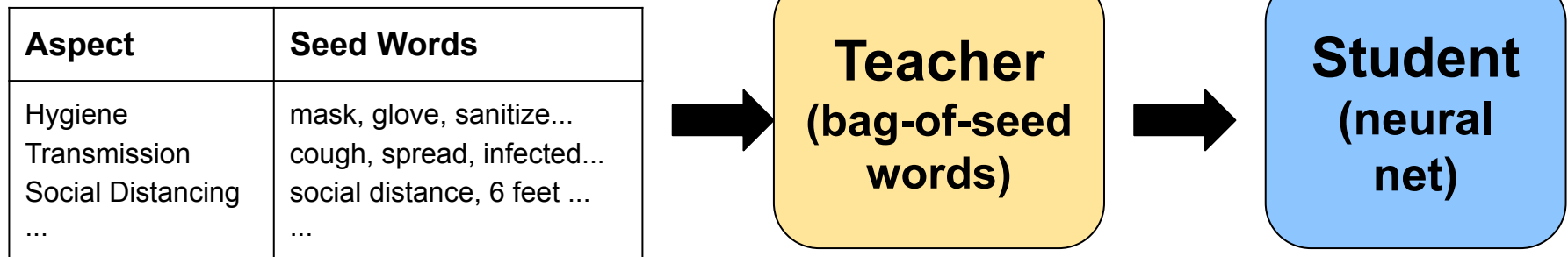 Classifies review by fine-tuning BERT with a classification head

COVID-19 Aspect Detection

Task: Classify review text into COVID-19 aspects

Fully Supervised approach: Leverage manually labeled data

Weakly-Supervised [1]: Leverage aspect-specific keywords

- Teacher model: uses keywords and no labeled data
- Student model: uses Teacher's predictions on unlabeled data

Aspect	Seed Words
Hygiene Transmission Social Distancing ...	mask, glove, sanitize... cough, spread, infected... social distance, 6 feet ... ...

➡️ **Teacher (bag-of-seed words)** ➡️ **Student (neural net)**

[1] Leveraging Just a Few Keywords for Fine-Grained Aspect Detection Through Weakly Supervised Co-Training, Karamanolakis et al. EMNLP '19

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

COVID-19 Aspect Detection Results

Target aspects: {Hygiene, Transmission, Social Distancing, Racism, Sympathy & Support, Services, Other}

BERT > BoW-SVM

Method	Binary F1	Multi-Class F1
Methods below are fully supervised		
BoW-SVM	0.739	0.422
BERT	**0.786**	**0.522**
Methods below are weakly supervised		
Teacher	0.605	0.270
Student-BERT	**0.657**	**0.407**

Student-BERT using labels from Teacher outperforms the Teacher

Extracted COVID-19 aspects could provide actionable insights

Outline

- COVID-19 and Restaurants
- New Dataset: Aspect-Annotated Yelp Reviews
- Experiments: COVID-19 Aspect Extraction
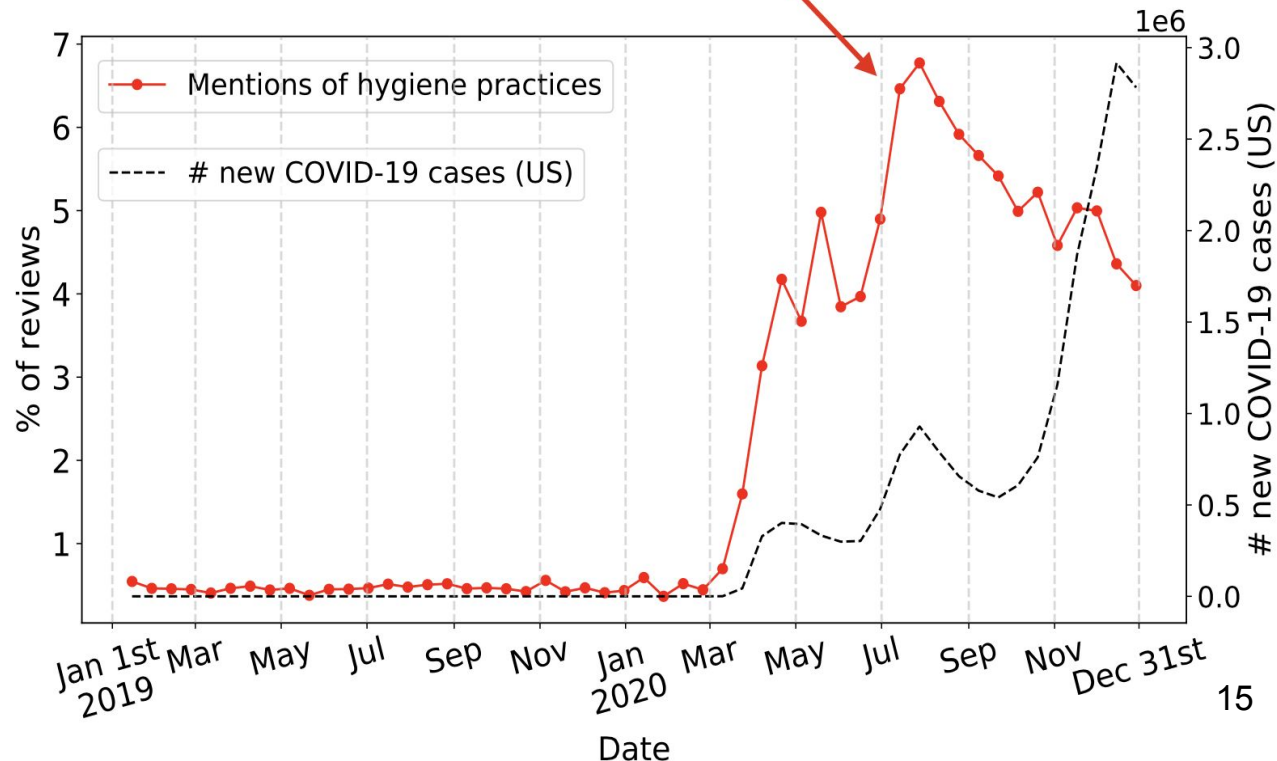- **Experiments: Time Series Analysis**
- Conclusion

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Time Series Construction

Goal: study how reviews change before and after the pandemic(Mar 1st).

% of reviews mentioning **Hygiene** aspect

How have ratings changed over time?

Compute average star rating over time for NYC and LA.

Findings:

Average rating **dropped** after March and then **increased** after June.

See findings on **extreme** ratings and specific rating **trends** in paper.

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

16

Yelp Statistics Correlate with COVID Statistics

Compute correlation between COVID aspects and # of new COVID cases

Correlation Analysis (Spearman)

Time Series (% of reviews)	NYC Cases	LA Cases
Social Distancing	0.768	0.347
Hygiene	0.765	0.395
Transmission	0.816	0.409
Sympathy & Support	0.822	0.490
Service	0.772	0.536
Racism	0.293	-0.006

Findings:

Both cities' time series show **strong correlation** with local COVID cases.

See **difference** between **local** and **national** COVID cases as well as correlation with **ratings** and **cuisine type** in the paper.

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Time series intervention analysis

Produce forecast of pre-pandemic statistics to check how it differed from real data

- Use Prophet Model for forecasting
- Train on pre-pandemic data (Jan 1st 2019 - Feb 28 2020)
- Predict a forecast for during COVID-19 and compare with true value

Intuition: if pandemic doesn't affect the result, then the Prophet model would be expected to predict values for 2020 that are near the observed values
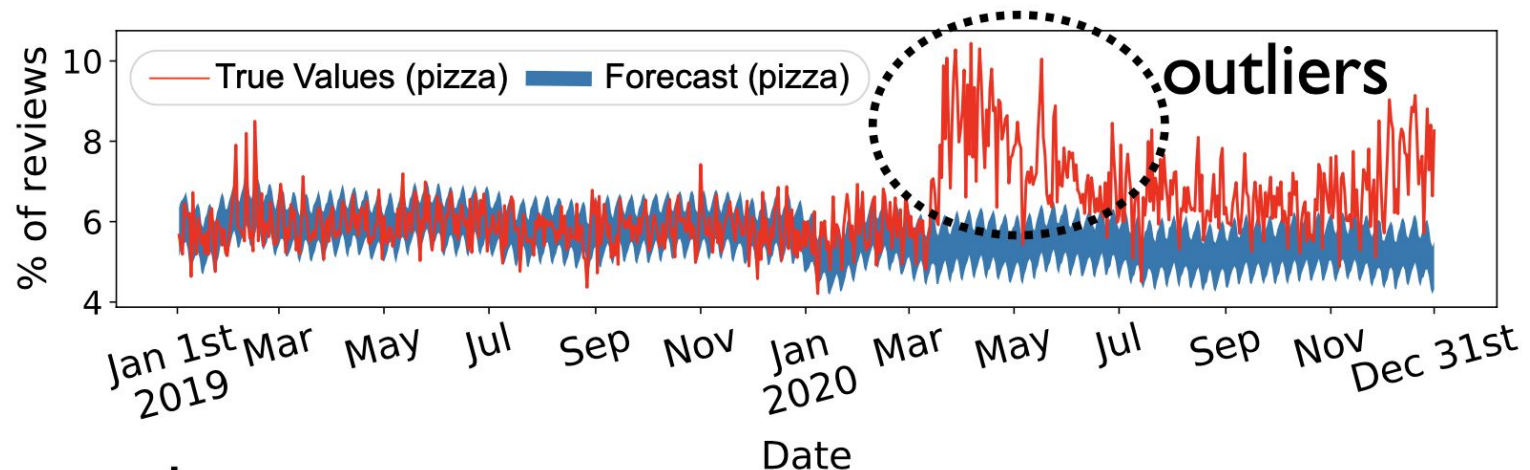
Time series intervention analysis

Produce forecast of pre-pandemic statistics to check how it differed from real data
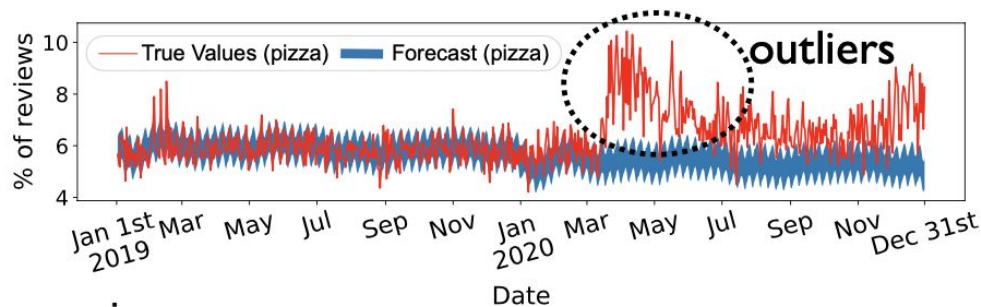
Time Series	% of outliers	
	LA	NYC
Grocery	82.35 ↑	96.54 ↑
Chicken Wings	64.36 ↑	92.73 ↑
Sandwiches	95.50 ↑	75.78 ↑
Hotdogs	77.85 ↑	65.05 ↑
Pizza	89.96 ↑	56.75 ↑
Breakfast&Brunch	81.31 ↓	53.98 ↓
Bars	69.90 ↓	59.86 ↓
Japanese	40.83 ↓	61.24 ↓
Asian Fusion	41.87 ↓	76.47 ↓
New American	89.62 ↓	91.70 ↓

Findings: changes in customer habits

- Fast Food and Grocery are reviewed **more** often than before the pandemic.

- American and Asian cuisine are reviewed **less** often than than before the pandemic.

Our findings agree with studies for other countries

Future: further exploration of our results in collaboration with health departments

Outline

- COVID-19 and Restaurants
- New Dataset: Aspect-Annotated Yelp Reviews
- Experiments: COVID-19 Aspect Extraction
- Experiments: Time Series Analysis
- Conclusion

Summary: Analysis of Yelp reviews before and during the pandemic

- Create **dataset** with COVID-19 aspects annotation
- Evaluate different models for **COVID-19 aspect detection**
- Observe **correlations** between COVID-19 statistics and reviews
- Find **shift of rating and user activity** during the pandemic

Our findings could provide insights for restaurant owners, customers, public health officials and broader research community!

Future work:

- Expand the regional coverage
- Improve aspect-based sentiment analysis by expanding new aspects
- Explore our results with health departments for future use

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Thank you

Ivy Cao, **Zizhou (Gary) Liu**, Giannis Karamanolakis, Daniel Hsu, Luis Gravano

Columbia University, New York, NY 10027, USA

{ic2502, zl2889}@columbia.edu, {gkaraman, djhsu, gravano}@cs.columbia.edu

Paper and dataset available at https://publichealth.cs.columbia.edu

Distribution of COVID-19 Aspects and Star Rating

Aspect	Star Rating					ALL
	1	2	3	4	5	
Hygiene	103	21	16	25	78	**243**
Non-COVID	39	13	14	28	117	**211**
Service	21	4	8	9	41	**83**
Social Distancing	9	2	8	8	40	**67**
Sympathy & Support	8	1	3	1	28	**41**
Transmission	26	6	4	1	2	**39**
Racism	30	1	0	0	2	**33**
Other	14	1	3	0	3	**21**

Trends of general restaurant types
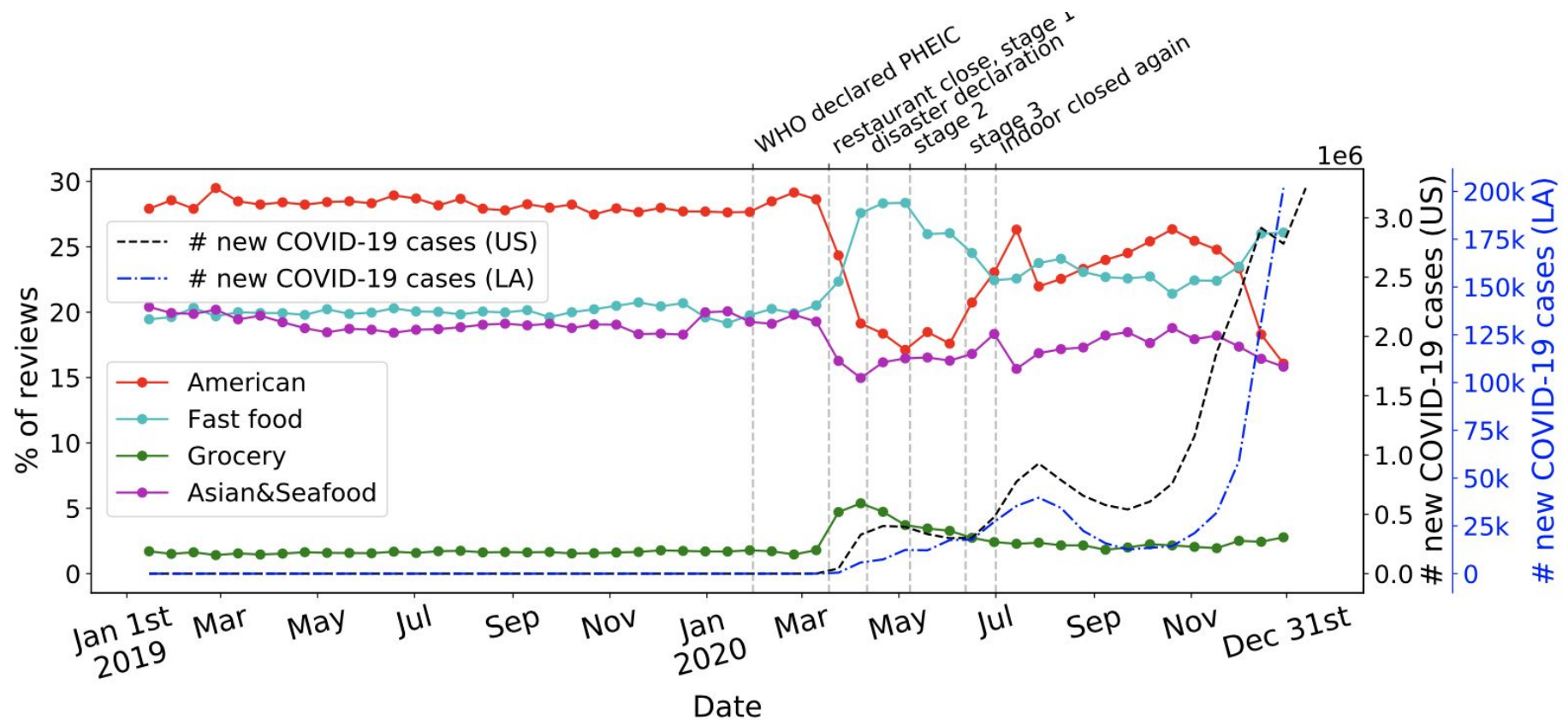
Percentage reviews for individual ratings(NYC)