

# Understanding COVID-19 Vaccine Campaign on Facebook using Minimal Supervision

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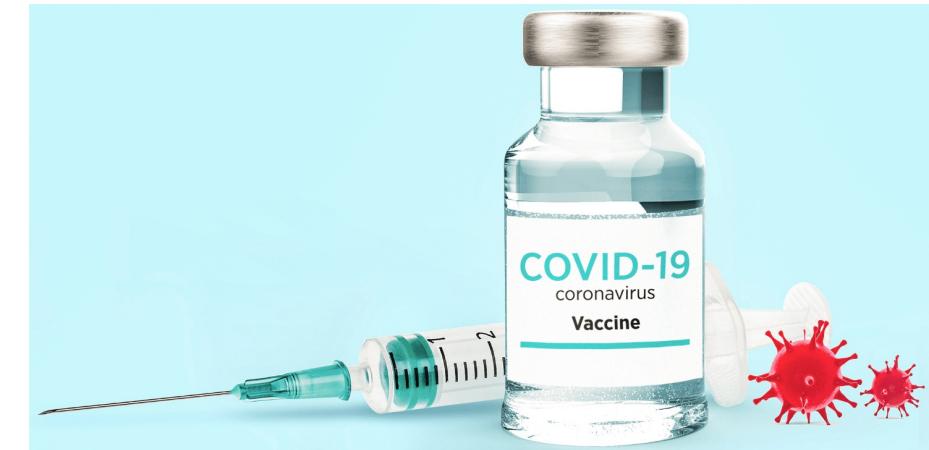
IEEE BigData 2022

*Date: December 17-20, 2022*



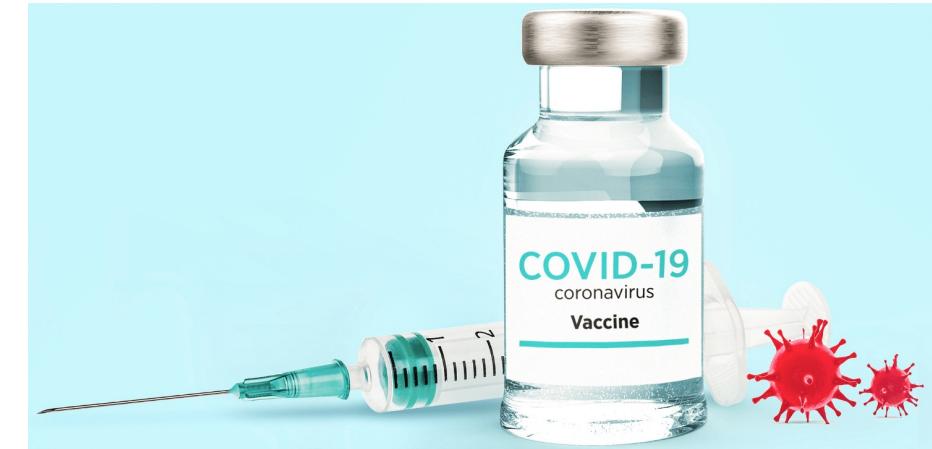
# COVID-19 Global *Infodemic*

- **Polarizing** information in **Social Media**.



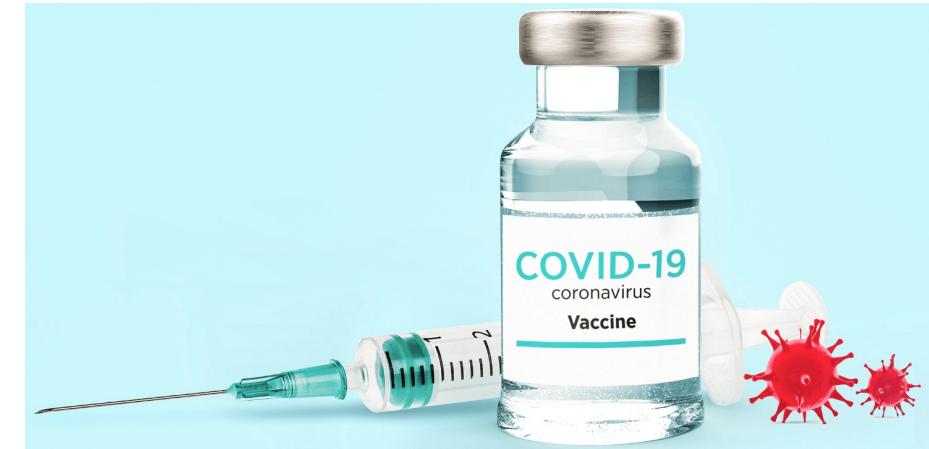
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- **Polarizing** information in **Social Media**.
- **Jeopardize** measures to **control** the pandemic.
  - creating panic, vaccine hesitancy, and fragmented social response.



# COVID-19 Global Infodemic

- **Polarizing** information in **Social Media**.
- **Jeopardize** measures to **control** the pandemic.
  - creating panic, vaccine hesitancy, and fragmented social response.
- **Increase polarization** around topics related to **vaccine mandate, vaccine efficacy, religious sentiment, vaccine equity** etc.



# Moral Foundation

- **Moral Foundation Theory (MFT)** suggests a theoretical framework for analyzing **morality** (Haidt 2004).
  - **6 moral foundations (MFs).**

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**CARE/HARM:** Saying that someone other than the speaker deserves care or gets harmed. Reflects the base of Maslow's Hierarchy of Needs [3]. Security, Shelter, Food, Water, Warmth.

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**FAIRNESS/CHEATING:** Justice, rights, and autonomy, comparison to other groups. Equality of Opportunities. Social Intolerance to "Free-Rider".

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- Correlation between the **vaccine debate** and its **MF**.

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# Microtargeting

- Facebook allows advertisers to **adapt** their messaging to **target** audiences.

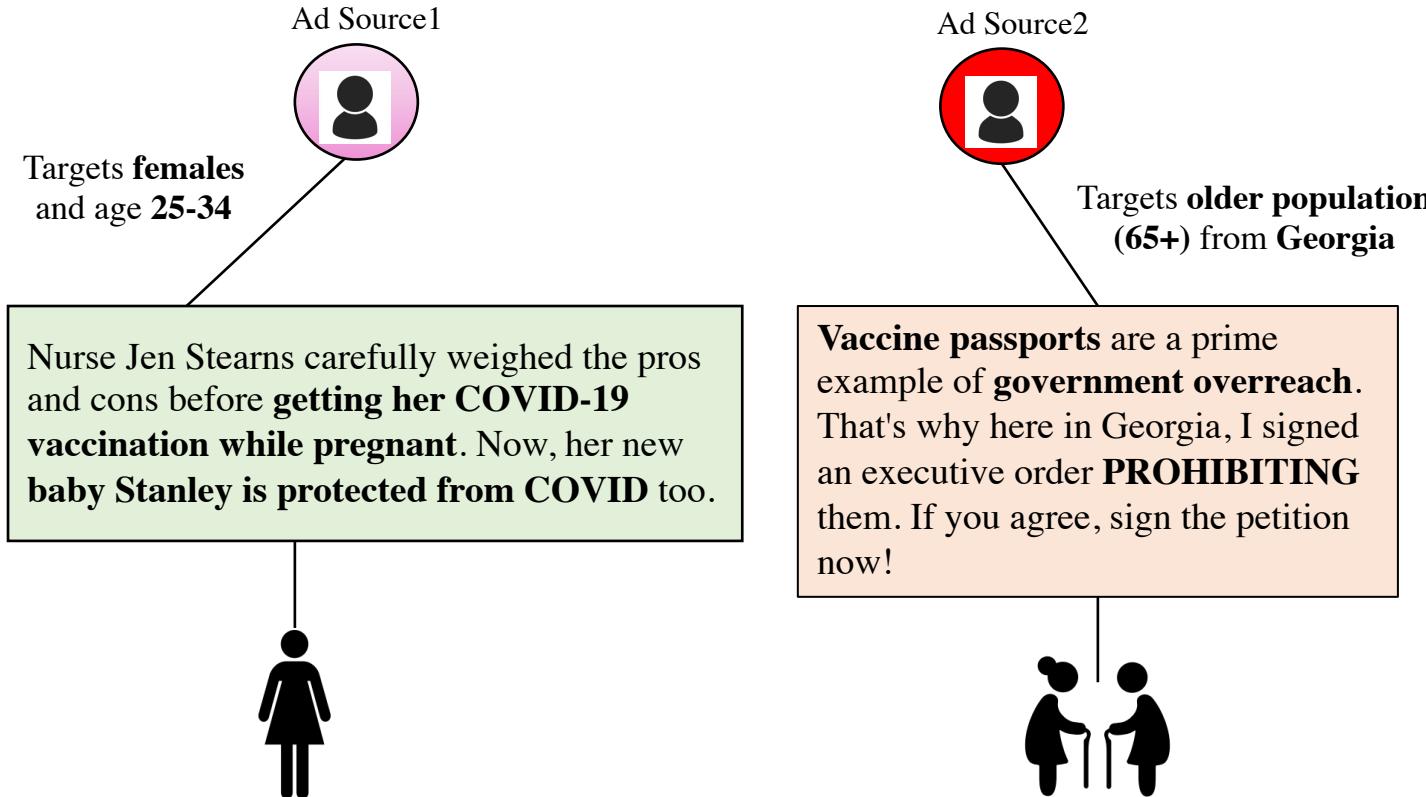


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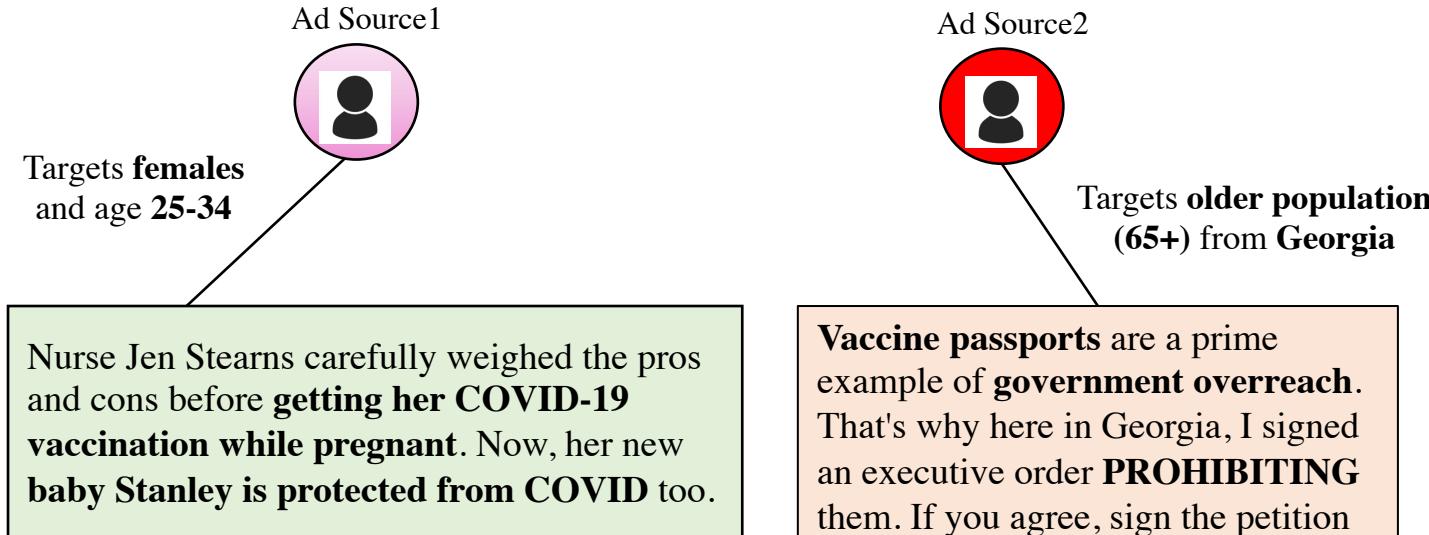
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# Microtargeting & Messaging Analysis



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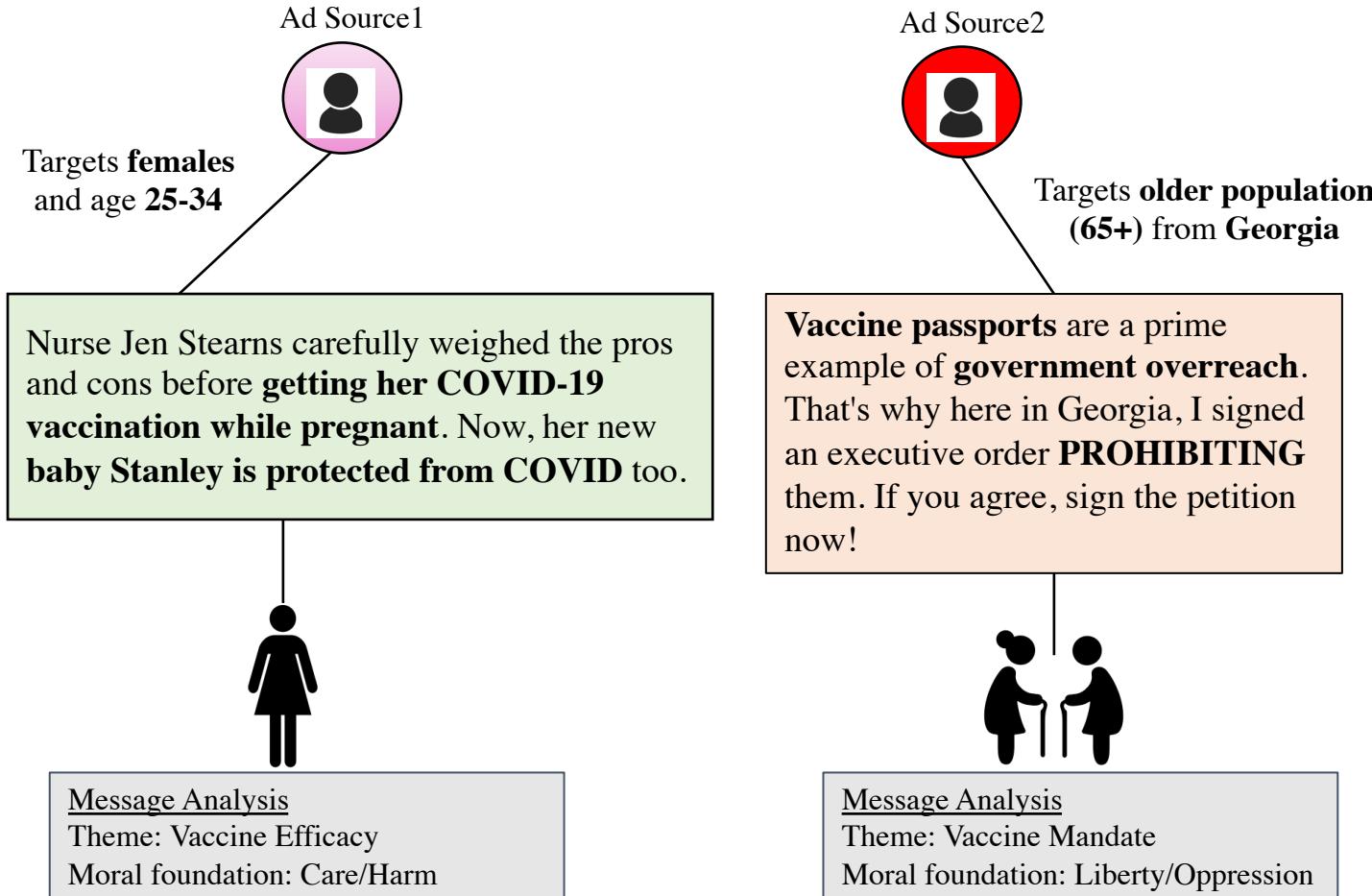


## Message Analysis

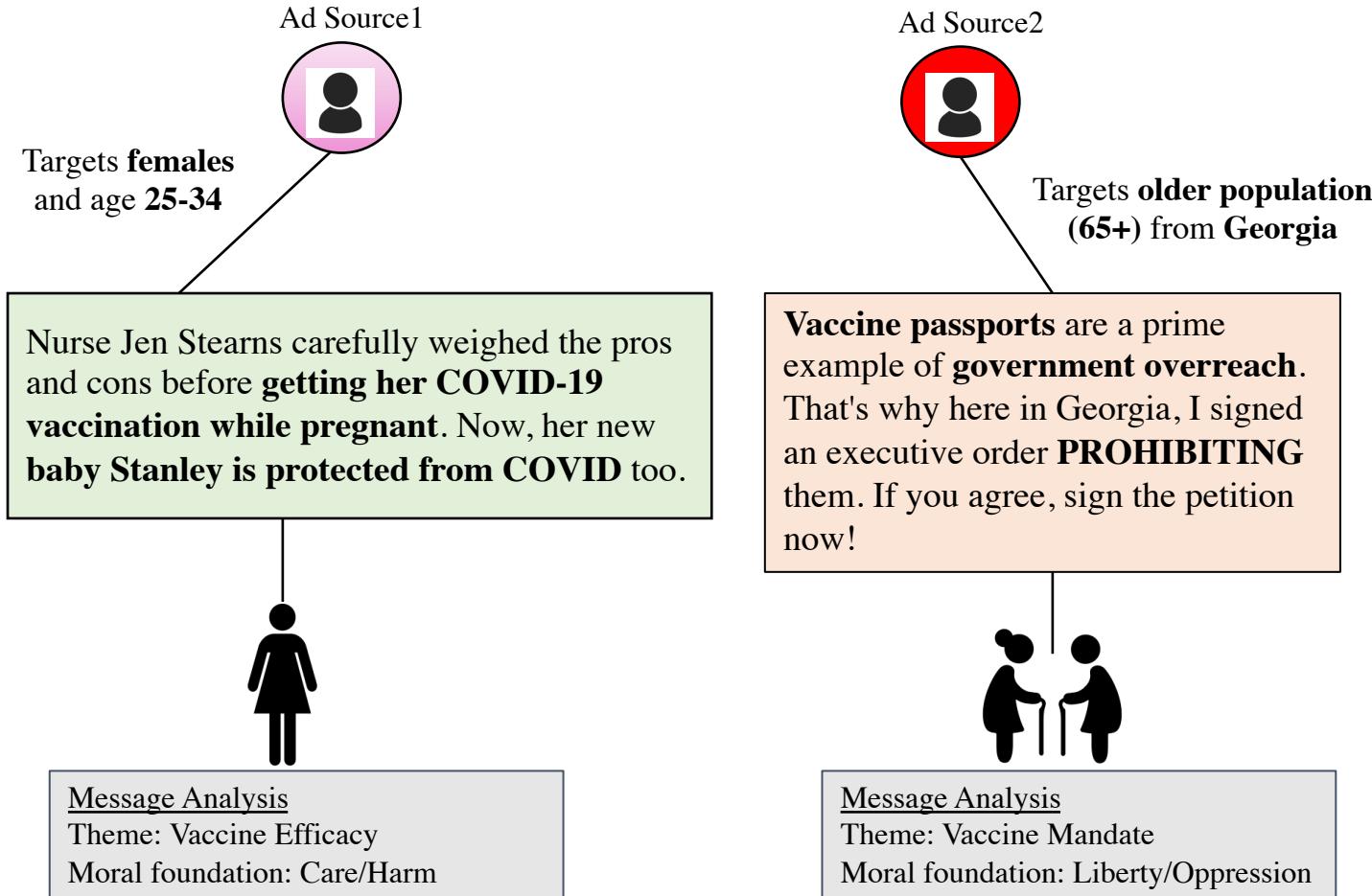
Theme: Vaccine Efficacy

Moral foundation: Care/Harm

# Microtargeting & Messaging Analysis



# Microtargeting & Messaging Analysis



**Our Work:**  
Analyze and shed light on how messaging is crafted for the different demographic groups.

# Vaccine Campaigns on Facebook



**Ken King**

Sponsored • Paid for by Ken King for State Representative

Biden's radical vaccine mandate would force companies with 100 or more employees to require proof of vaccination or have their employees undergo weekly testing. I have joined my conservative colleagues and Texans for Responsible Government in an amicus curiae brief to overturn this outrageous order. No one should be forced to have a medical procedure in order to keep thei...



**Long Beach Department of Health & Human Services (LBDHHS)**

Sponsored • Paid for by Long Beach Dept. of Health & Human Services

It's everyone's turn. You wouldn't drive your kids to school without the protection of seatbelts. Protect your loved ones 12 and older by getting the COVID-19 vaccine. #SleeveUpLB



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**Theme:**  
*Vaccine Mandate*

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**Moral Foundation:**  
*Liberty/Oppression*

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# *Vaccine Campaigns on Facebook*

**Theme:**  
*Encourage Vaccination*



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**Moral Foundation:**  
*Loyalty/Betrayal*



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**Theme:** Vaccine Mandate

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**Theme:** Encourage Vaccination

**Moral Foundation:** Loyalty/Betrayal

# Our Goal

- Formulate a novel problem of using **minimal supervision** to analyze the **landscape of vaccine campaigns** on Facebook.

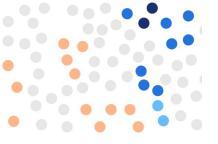
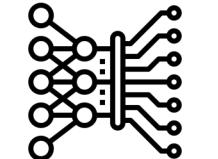
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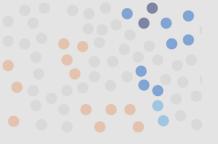
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- Conduct details analysis of messaging across different **demographics, geographic, and timelines**.

# Roadmap

	Dataset Details
	Weak Label Generation
	Brief Description of the Framework
	Analysis of Messaging

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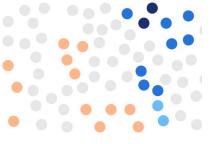
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- For each ad, the API provides ad ID, title, ad body, funding entity, ad creation time, ad span, spend, impressions, distribution over impressions broken down by gender, age, location down to states in the USA.
- **9,920** ads with different contents.
- Ground Truth: **557** ads.
- Annotators are provided **23 examples** covering all six moral foundations and **theme definition of 15 themes**.
- Subset of ads (20%): **2 annotators, 1 male & 1 female, age range 30-40.**
- Inter-annotator agreement: **Cohen’s Kappa** coefficient
  - Theme: **65.60%**
  - MF: **73.80%**

# Roadmap

	Dataset Details
	Weak Label Generation
	Brief Description of the Framework
	Analysis of Messaging

# Weak Label for *Themes*

- Set of themes from recent works: reasons of supporting vaccination and vaccine hesitancy.

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e.g.,

*“Protect our community by getting vaccinated”*

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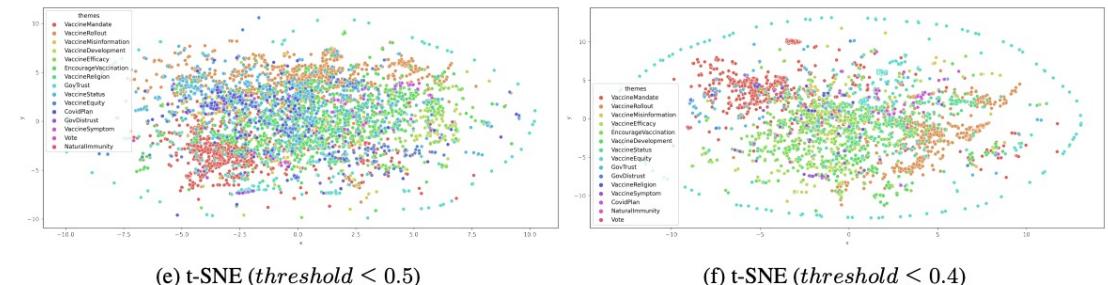
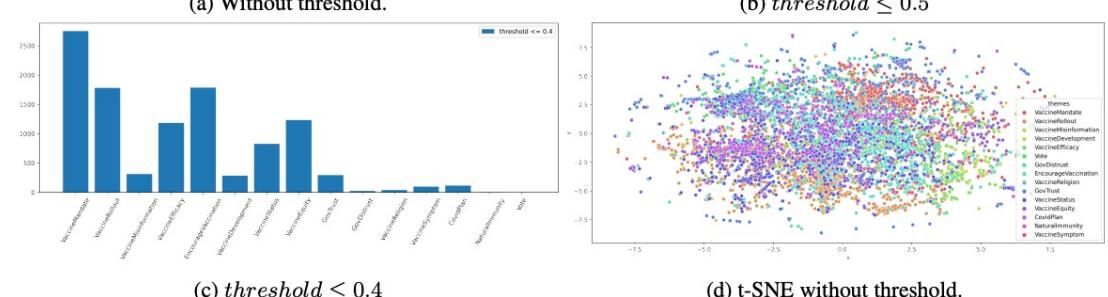
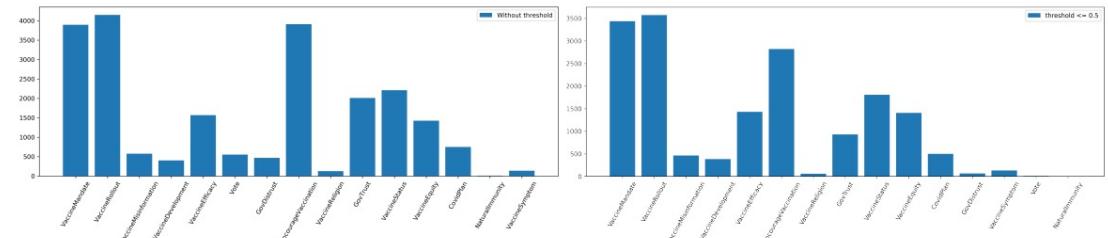
- **Add new themes and phrases** related to COVID-19 vaccine campaigns.

e.g.,

“*Protect our community by getting vaccinated*”      **Theme:** Encourage Vaccination

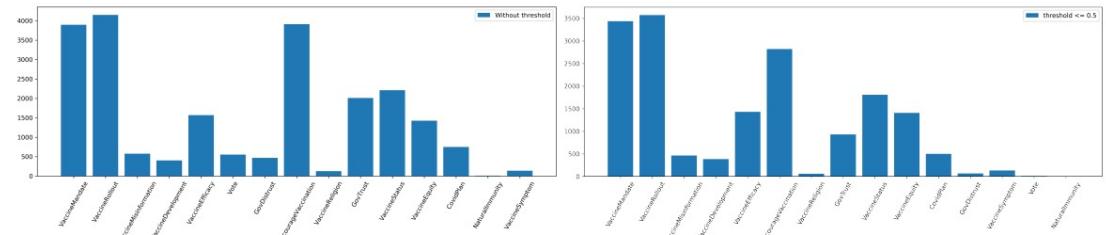
# Assign Themes

- **Ground the phrases** in a set of COVID-19 vaccination ads and **match similarity** between their **Sentence BERT** embeddings.



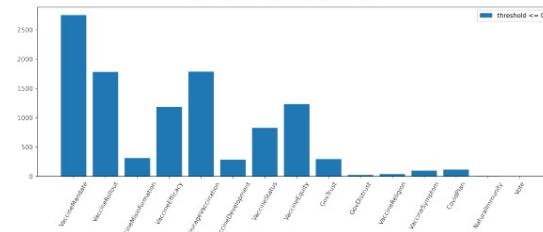
# Assign Themes

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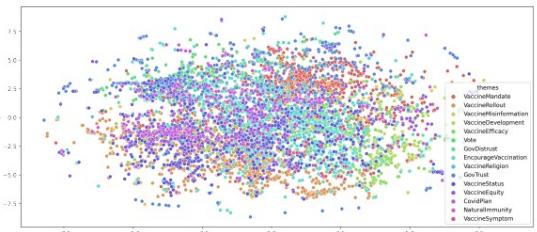


(a) Without threshold.

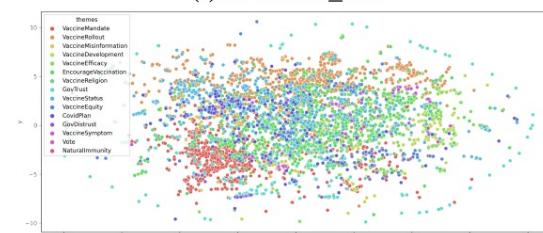
(b)  $\text{threshold} \leq 0.5$



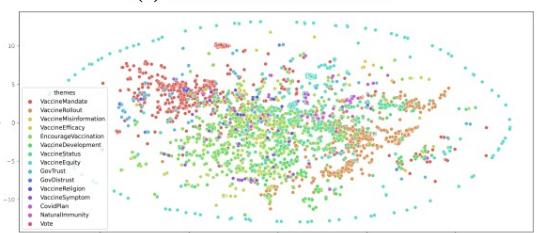
(c)  $\text{threshold} \leq 0.4$



(d) t-SNE without threshold.



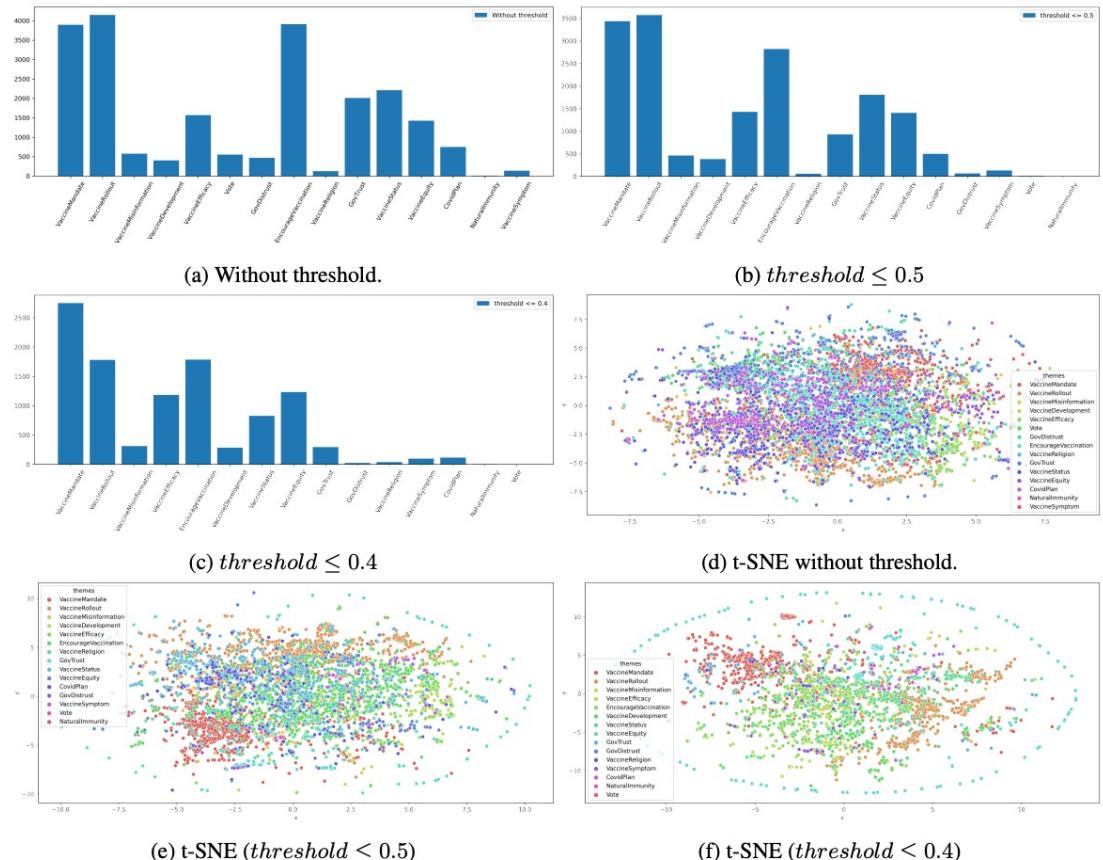
(e) t-SNE ( $\text{threshold} \leq 0.5$ )



(f) t-SNE ( $\text{threshold} \leq 0.4$ )

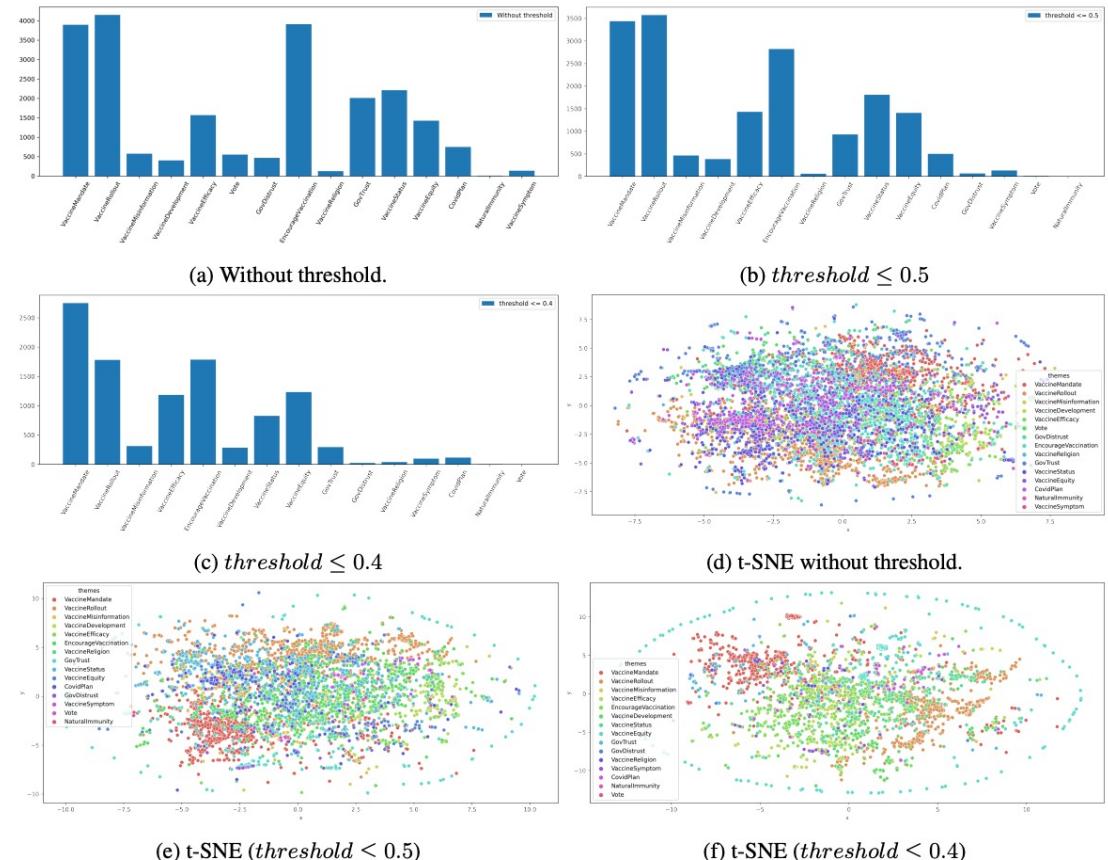
# Assign Themes

- **Ground the phrases** in a set of COVID-19 vaccination ads and **match similarity** between their **Sentence BERT** embeddings.
- Cluster purity: **Silhouette score**
- **Limit assignment**: threshold



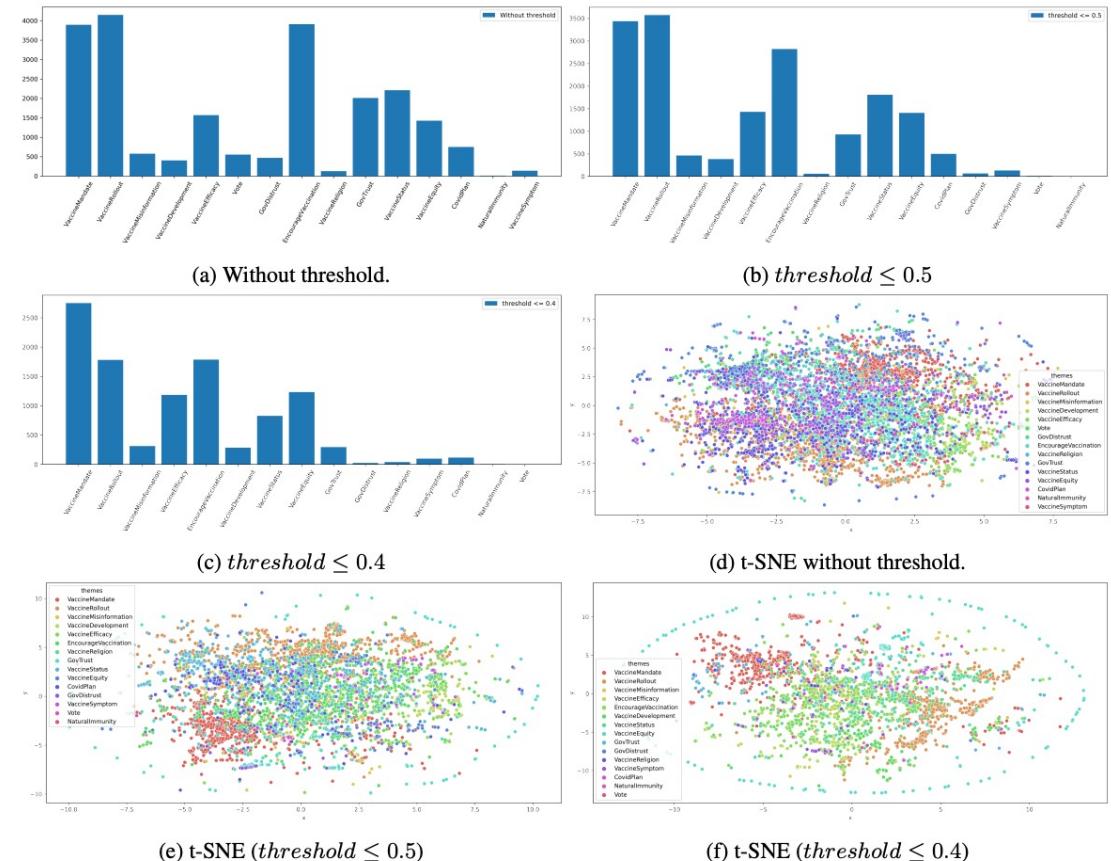
# Assign Themes

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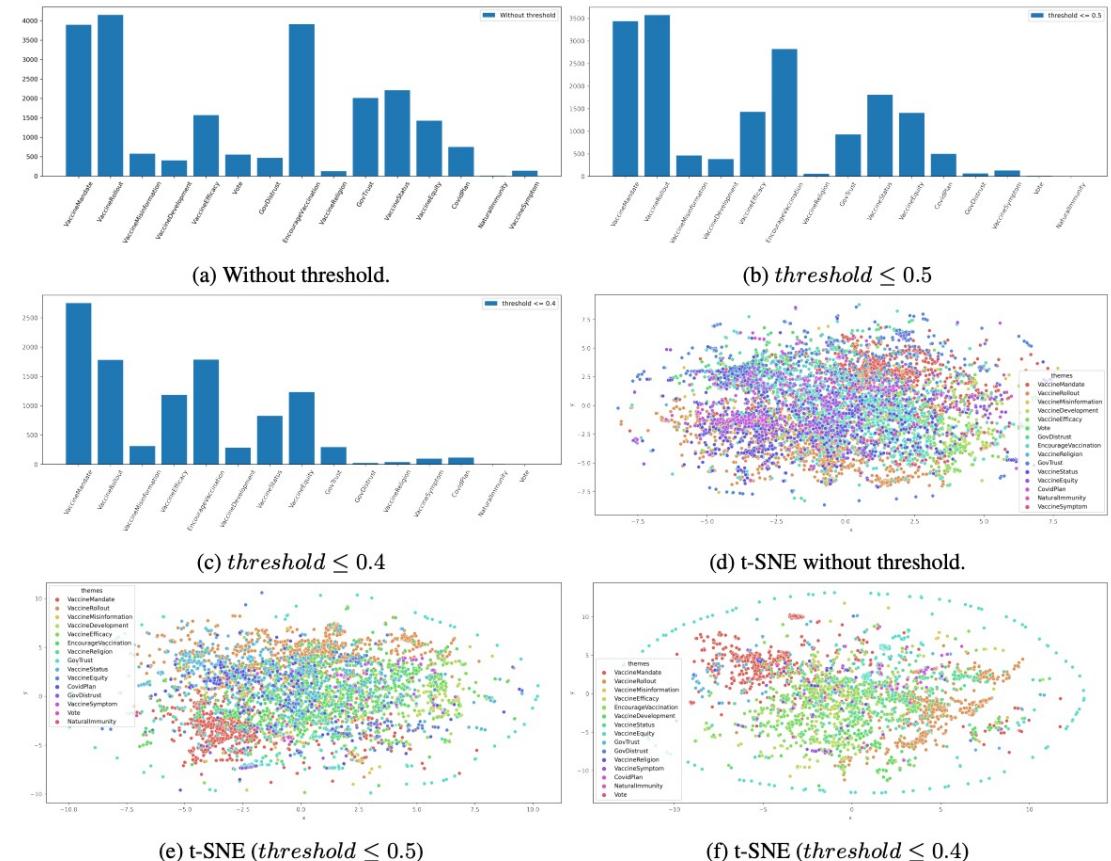
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  - Accuracy: **51.3%**
  - Macro-avg F1: **33.7%**



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- Quality of weak label:
  - Accuracy: **51.3%**
  - Macro-avg F1: **33.7%**
  - Significantly better than random (**6.7%**)



# Weak Label for *MF*

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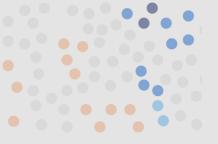
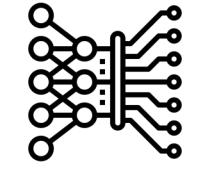
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  - Ad contains  $\geq$  two keywords.
- Quality of weak label:
  - Accuracy: **41.7%**
  - Macro-avg F1: **24.8%**

# Weak Label for *MF*

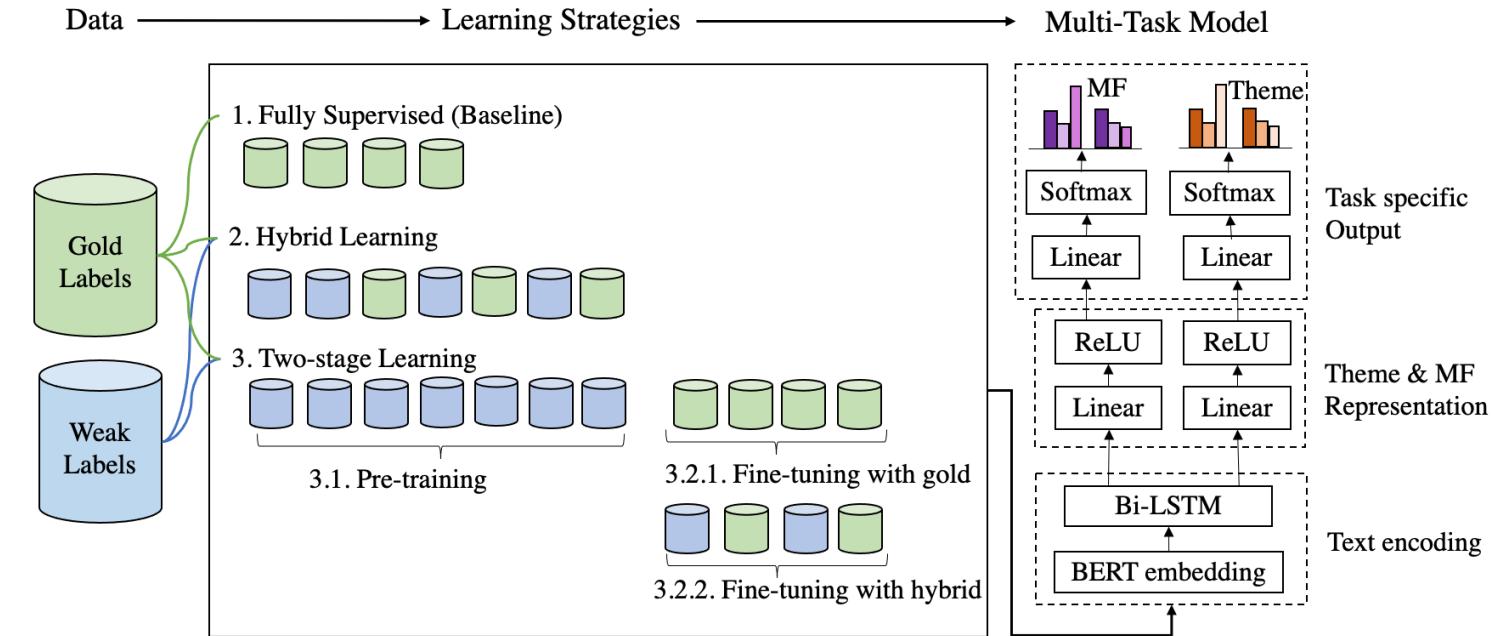
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  - Comparatively better than random (**14.3%**)

# Roadmap

	Dataset Details
	Weak Label Generation
	Brief Description of the Framework
	Analysis of Messaging

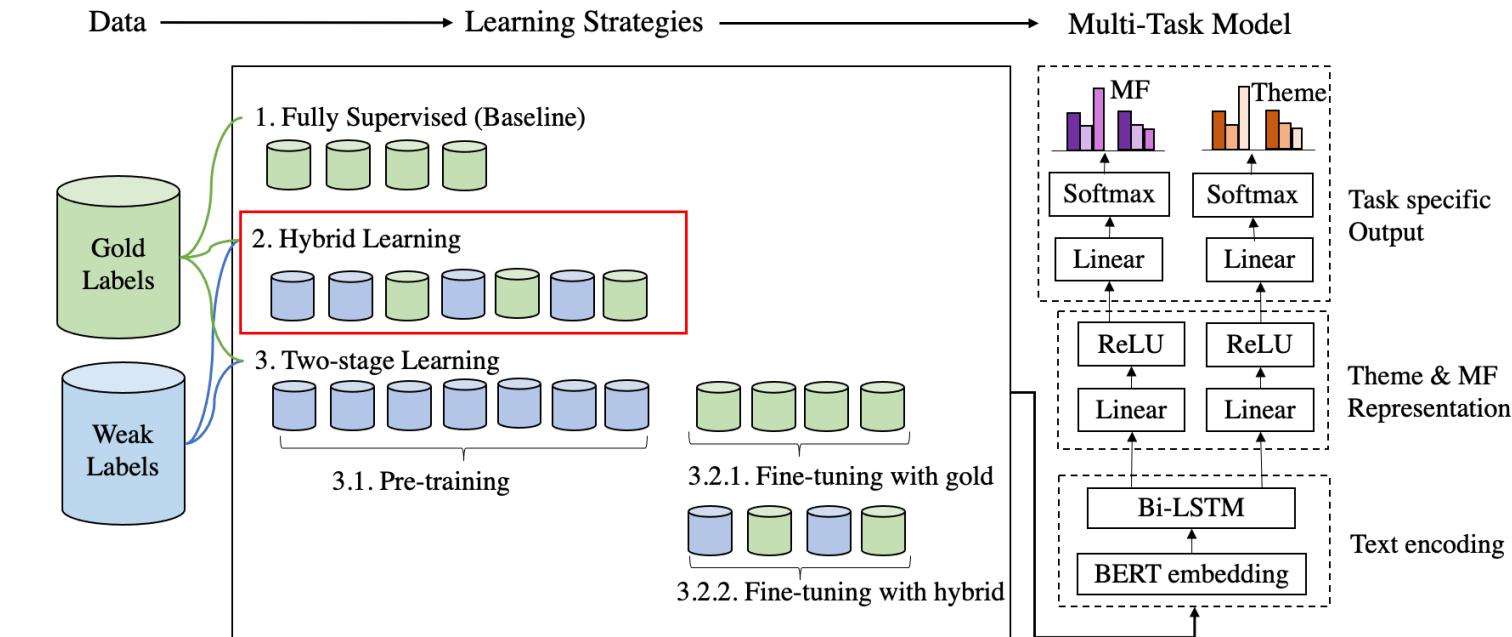
# Learning Strategies

- 3 learning strategies.



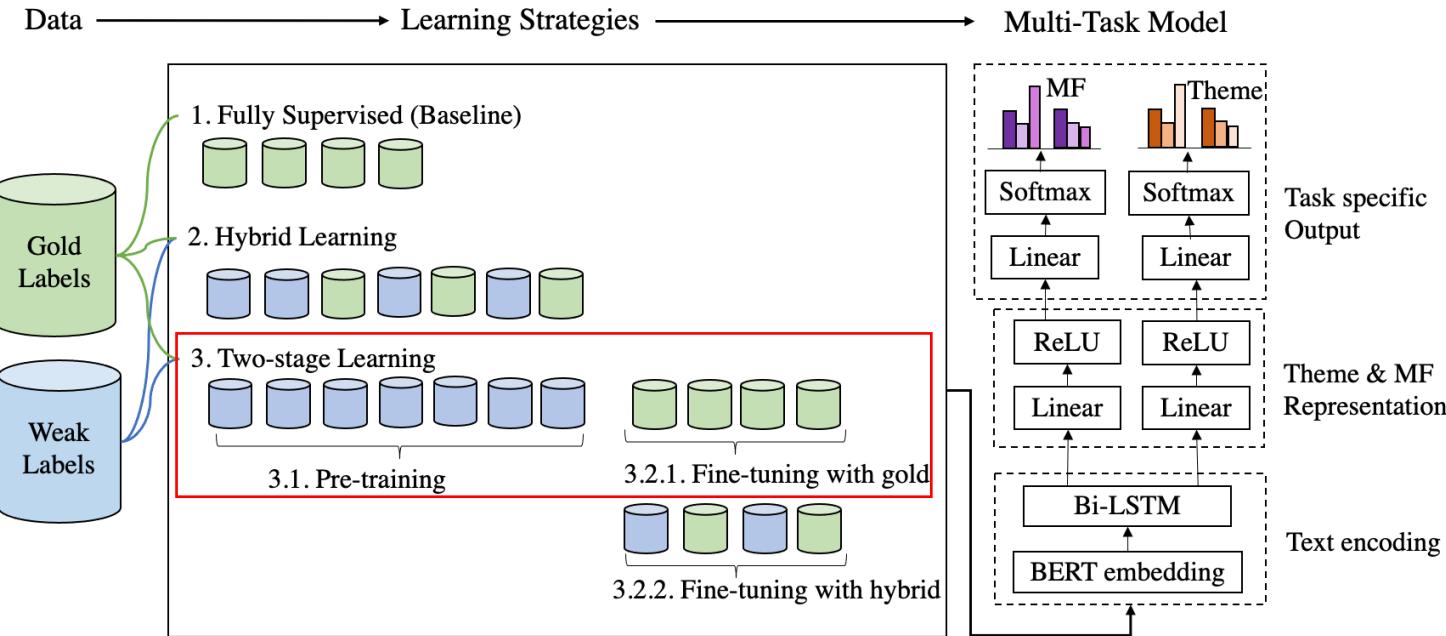
# Learning Strategies

- 3 learning strategies.
- **Hybrid Learning:** uses mixture of gold and weak labels for training.



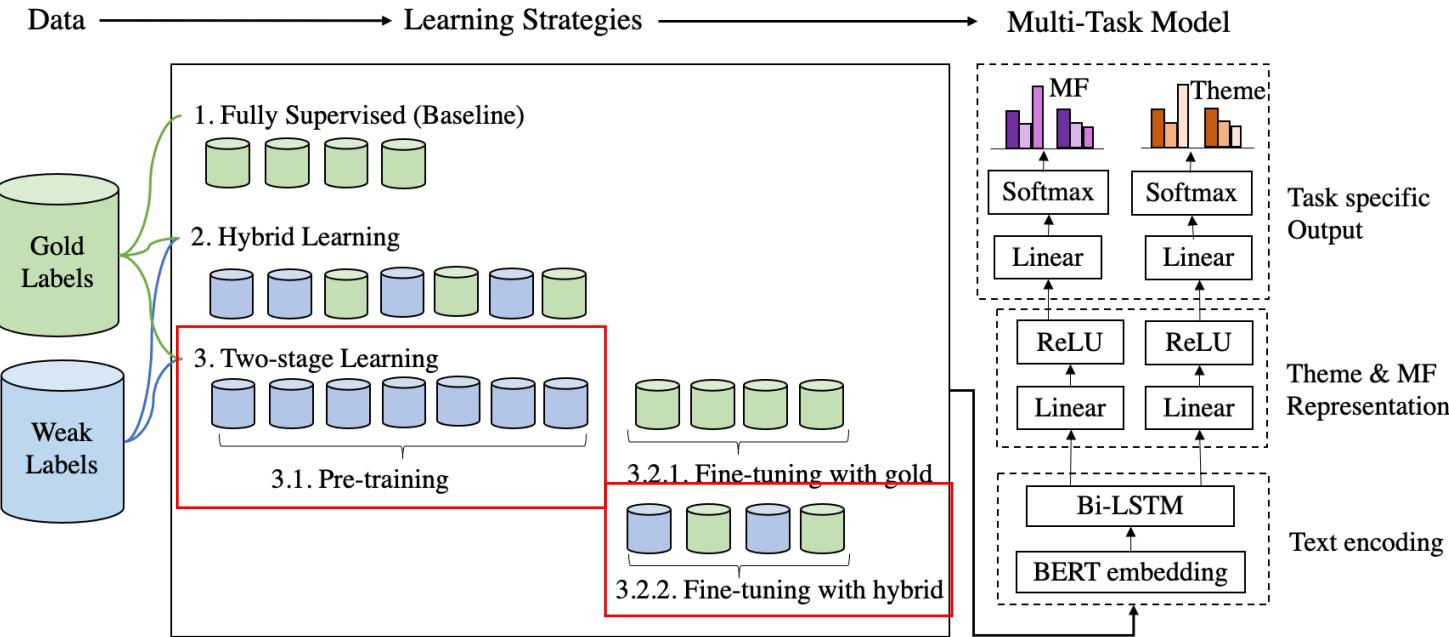
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- **Two-stage learning1:** pre-training using a large but noisy dataset, fine-tuning using gold labels.



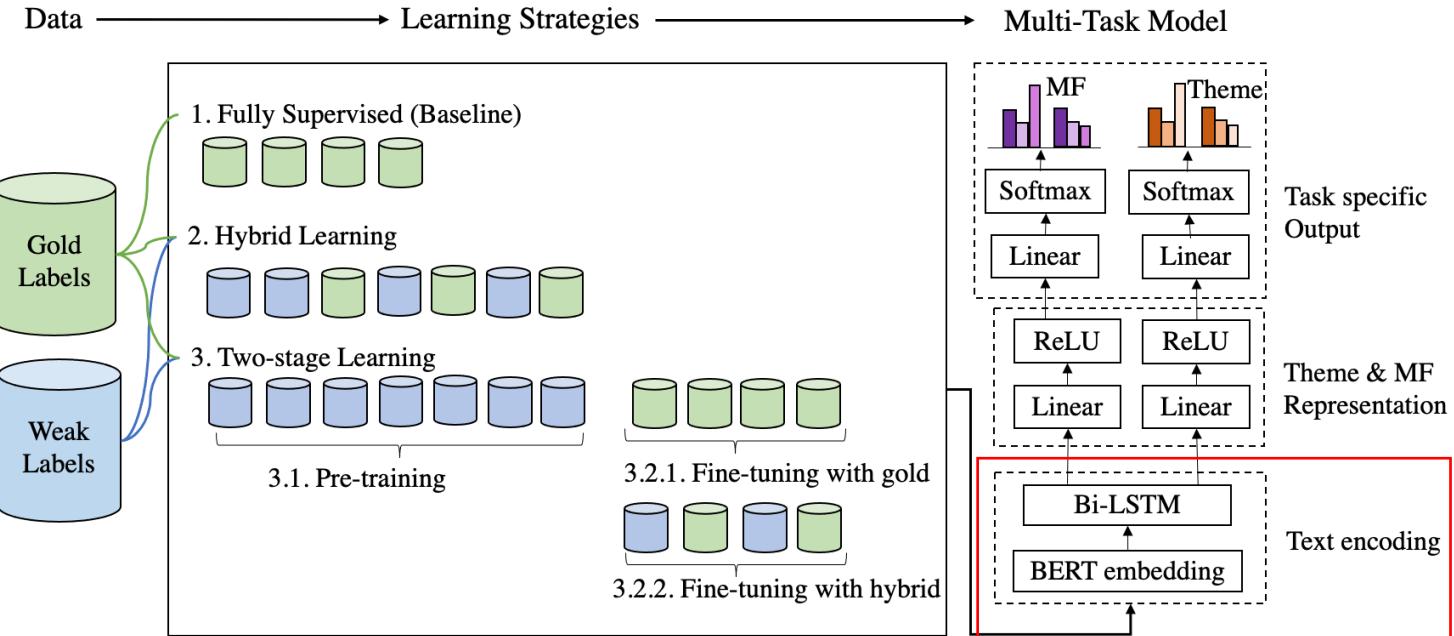
# Learning Strategies

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- **Two-stage learning1:** pre-training using a large but noisy dataset, fine-tuning using gold labels.
- **Two-stage learning2:** pre-training using noisy dataset, fine-tuning using weak + gold labels.



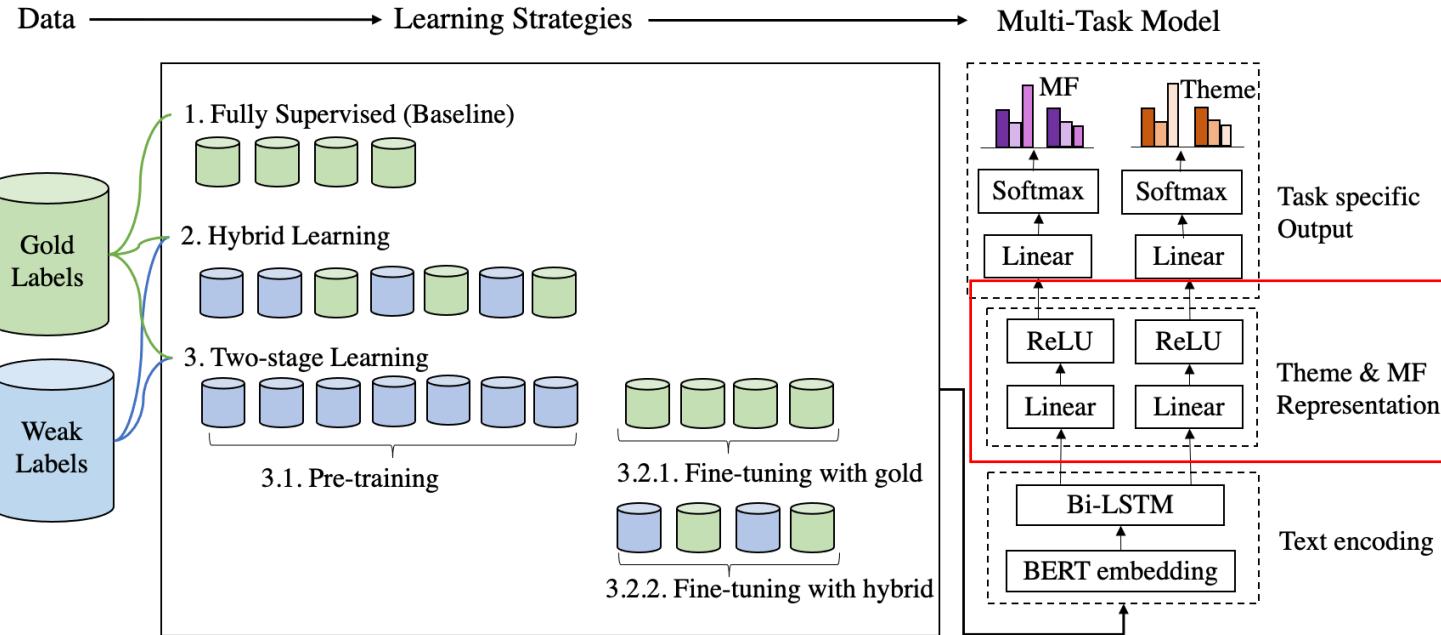
# Multi-task Learning

- Text Encoder: BERT embedding + Bi-LSTM



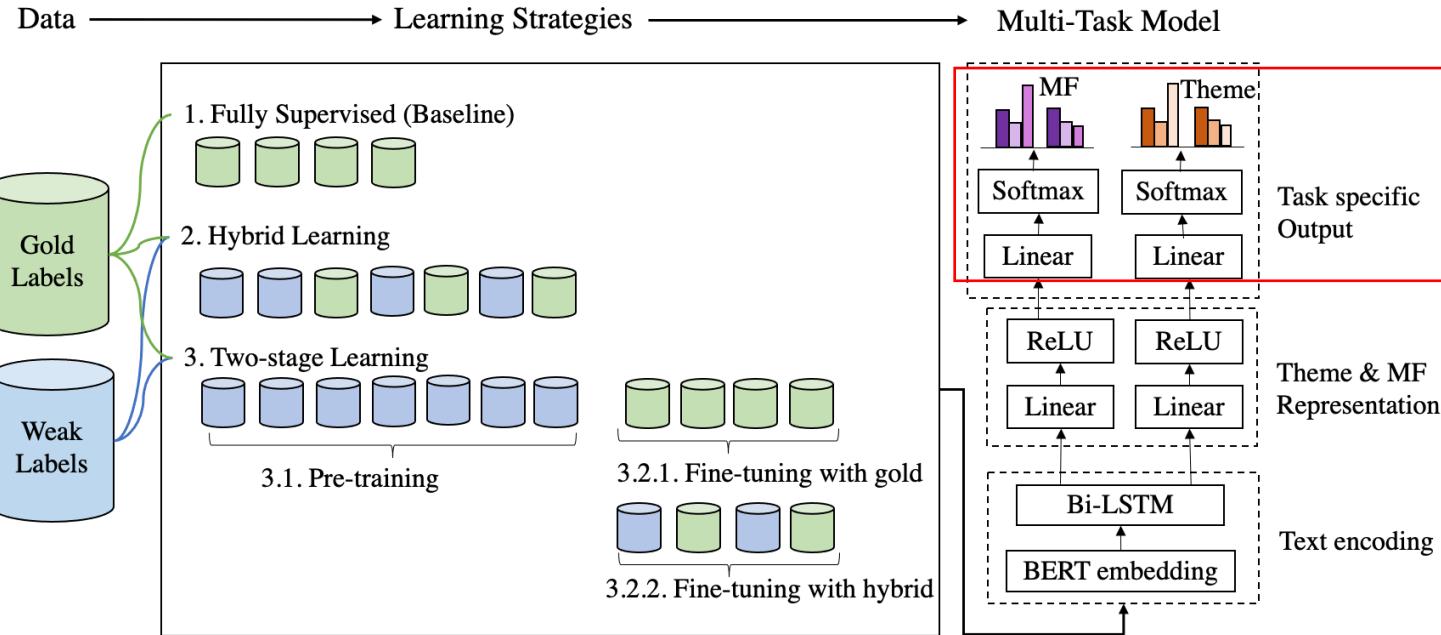
# Multi-task Learning

- Text Encoder: BERT embedding + Bi-LSTM
- Text Decoder: Linear + ReLU



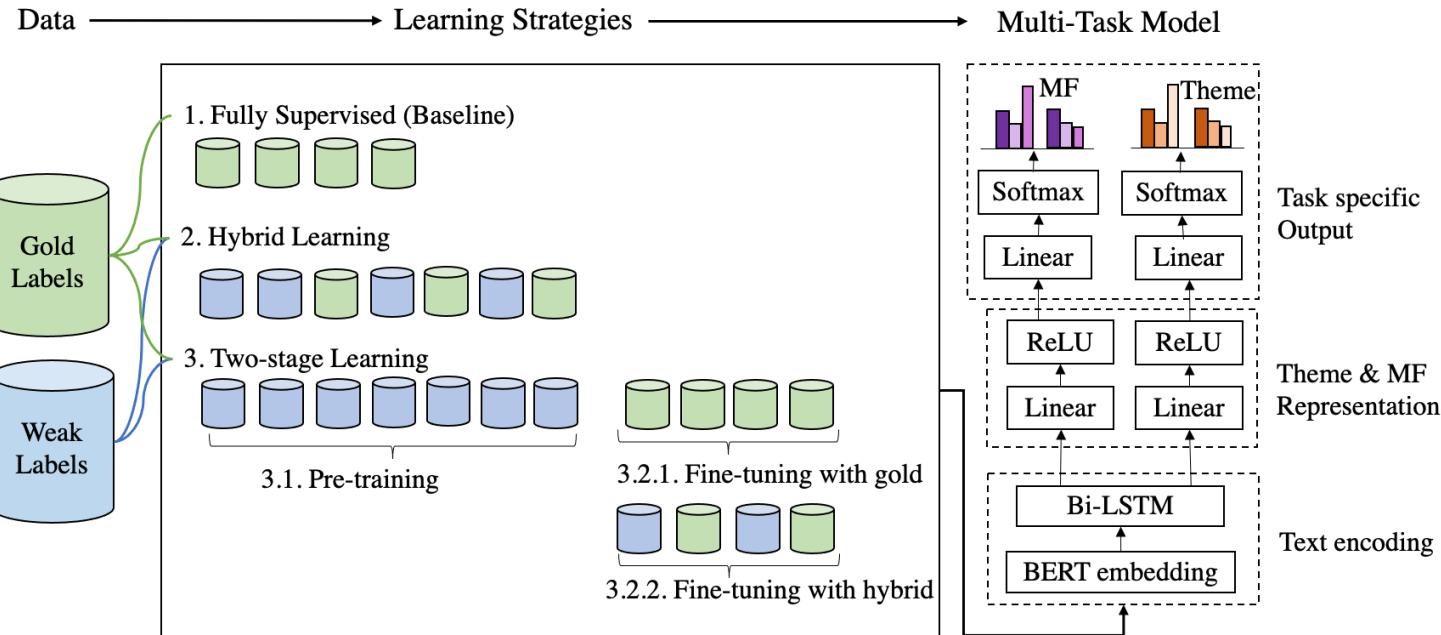
# Multi-task Learning

- Text Encoder: BERT embedding + Bi-LSTM
- Text Decoder: Linear + ReLU
- Task Specific Output: Linear + Softmax.



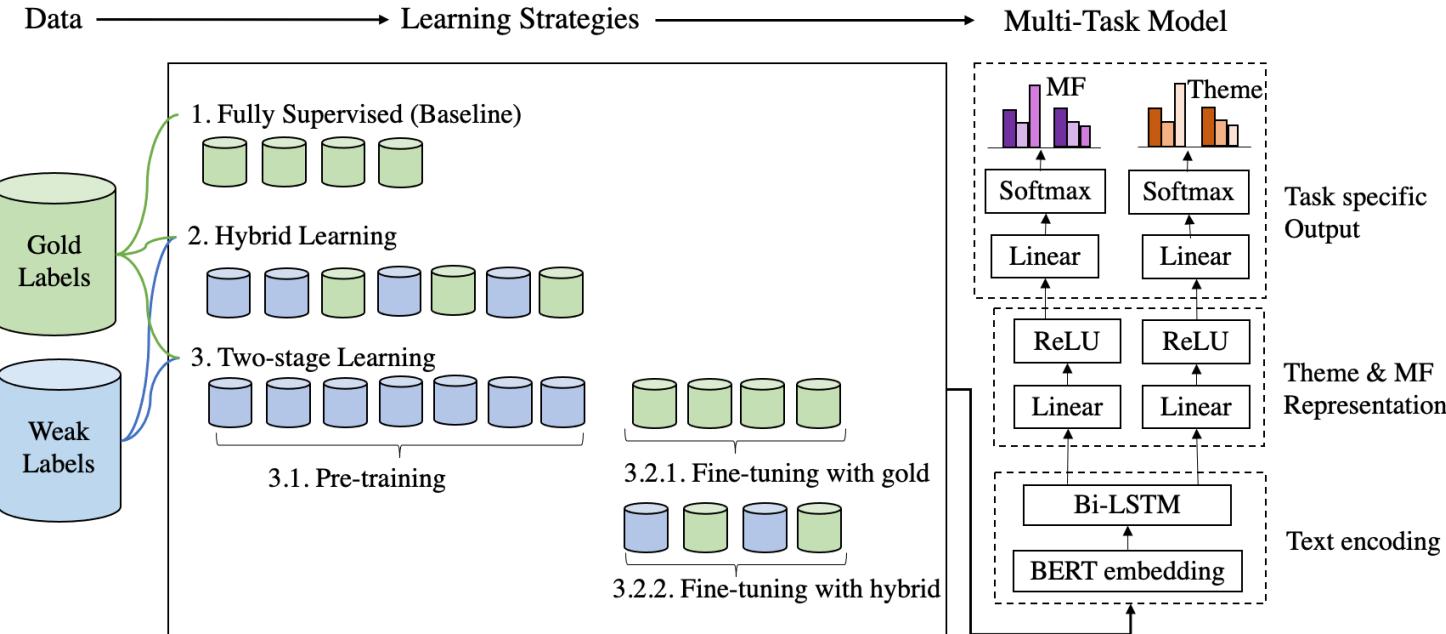
# Multi-task Learning

- Text Encoder: BERT embedding + Bi-LSTM
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- Objective Function: Sum of cross-entropy losses for both tasks.



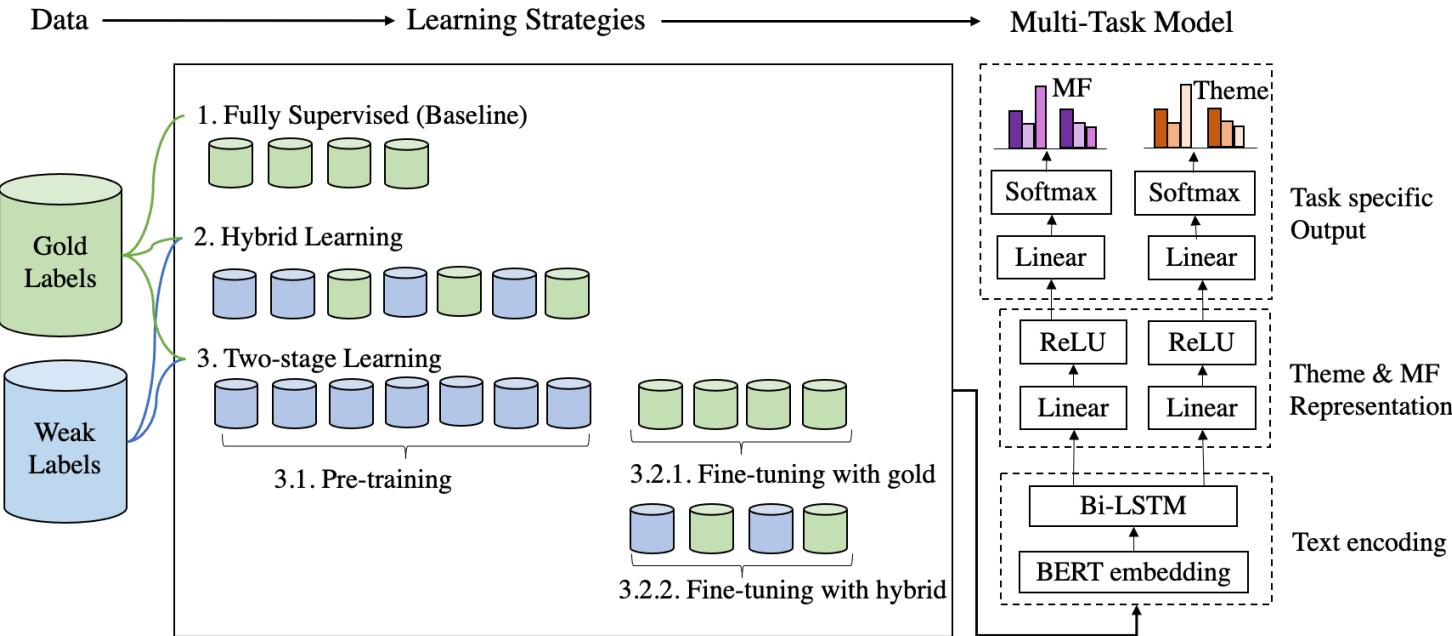
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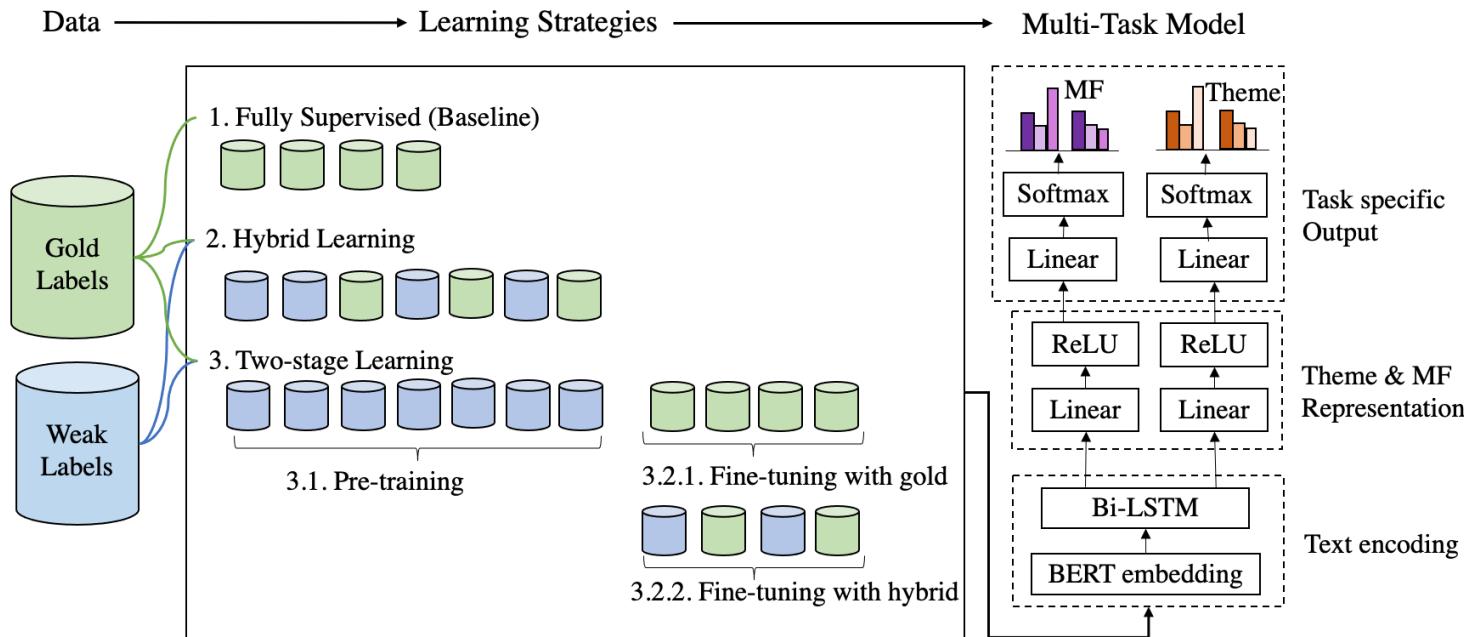
# Results

- Text Encoder: BERT embedding + Bi-LSTM
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- Task Specific Output: Linear + Softmax.
- Objective Function: Sum of cross-entropy losses for both tasks.
- **Hybrid learning** strategy achieves the best result.
  - **Theme:**
    - Accuracy: **69.0%**,
    - Macro-avg F1 **57.9%**.

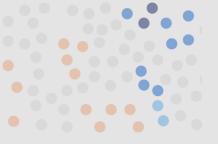


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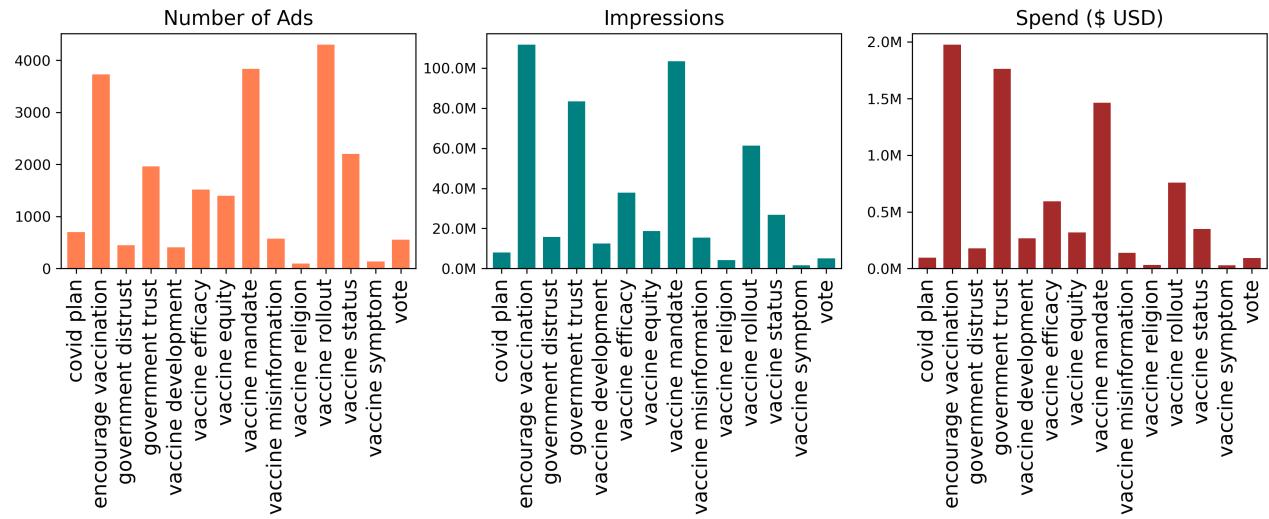
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- Text Decoder: Linear + ReLU
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- Objective Function: Sum of cross-entropy losses for both tasks.
- **Hybrid learning** strategy achieves the best result.
  - **Theme:**
    - Accuracy: **69.0%**,
    - Macro-avg F1 **57.9%**.
  - **MF:**
    - Accuracy: **75.2%**,
    - Macro-avg F1: **51.0%**.



# Roadmap

	Dataset Details
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	Analysis of Messaging

## RQ1: What are the narratives of the messaging?



help vaccination loved one  
pandemic good public health community  
shot say family got one  
click learn talk school students  
vaccine can choose appointment  
vaccinated like spread zaffra  
getting people work  
today prevent spread couple video  
question

## Encourage vaccination

member today  
comply  
trust  
take  
cannot  
least  
battle  
american  
fight  
up to  
right  
tear  
Companies  
bag  
selling  
wa  
preme court  
help  
branny  
e biden  
become  
resource  
win  
hidden administration  
becoming state

# Vaccine mandate

talk today  
governor  
president biden  
mandate  
news  
heath  
.com  
support  
thank  
one  
help  
vaccinated  
biden  
pandemic  
people  
presidentamerican  
american  
rescue  
right  
family  
school  
also  
tpua  
take  
fight  
against  
immigrant  
refugee  
vaccination  
center  
world discuss  
american  
right  
family  
school  
also  
tpua  
take  
fight  
against  
immigrant  
refugee

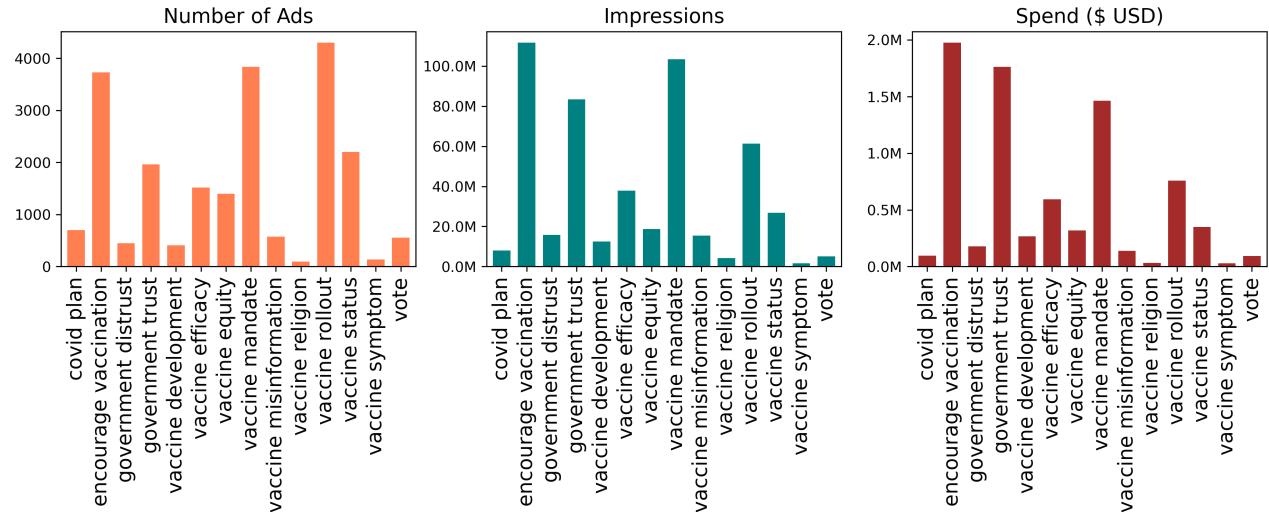
# Governmen trust

children safe convenient new individuals  
appointment community keep find help  
jordan jordan visit receive retention site  
also open clinic vaccination schedule  
partnership children flu available pfizer  
children also event information people  
emergency clinic vaccination available  
appointment necessary older Vaccinated  
read accessibility issues

# Vaccine rollout

# RQ1: What are the narratives of the messaging?

- Most popular theme **encourage vaccination** promoting vaccination to *protect their loved one, family, friends, and community* using **loyalty/betrayal** MF.



## Encourage vaccination

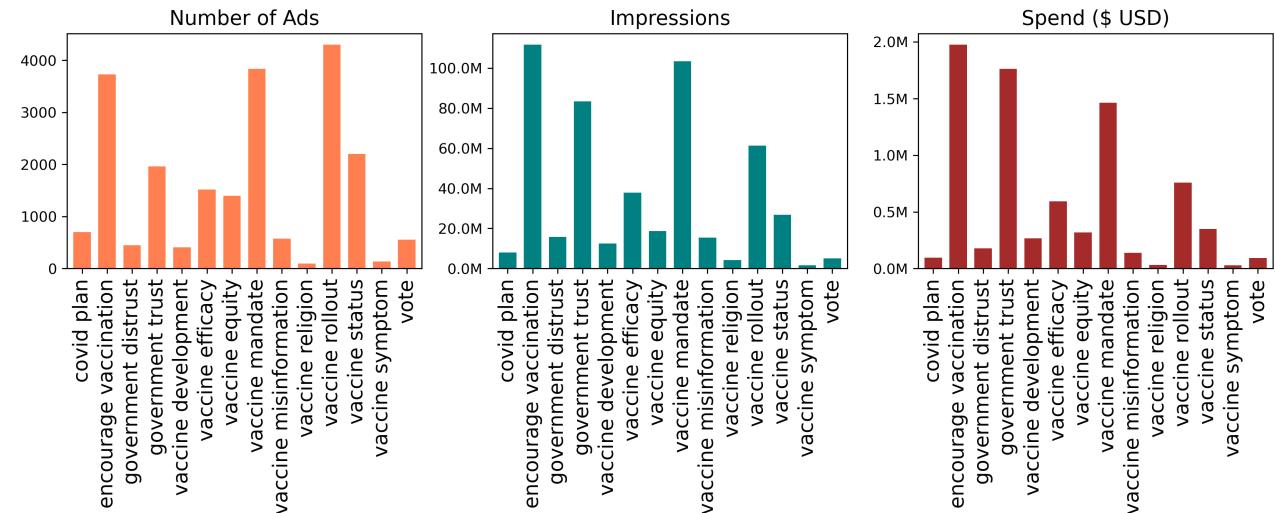
help vaccination loved one  
pandemic well-being public health  
shot protect say got one  
community family left individual  
click learn park health education  
vaccinated 20s appointment  
getting people 30s names  
today spread 40s question  
work

## Vaccine mandate

# Government trust

# RQ1: What are the narratives of the messaging?

- Most popular theme **encourage vaccination** promoting vaccination to *protect their loved one, family, friends, and community* using **loyalty/betrayal** MF.
  - Next most popular (impressions) category: **vaccine mandate** featuring narratives focusing *Biden's vaccine mandate respective to freedom and tyranny*.



Encourage  
vaccination

protect  
vaccination  
loved  
community  
got  
one  
shot  
say  
family  
left  
responsible  
click  
learn  
pik  
Health  
doctors  
selfs  
appointment  
pandemic  
life  
today  
spread  
people  
work  
question  
vaccinated  
getting  
people

# Vaccine mandate

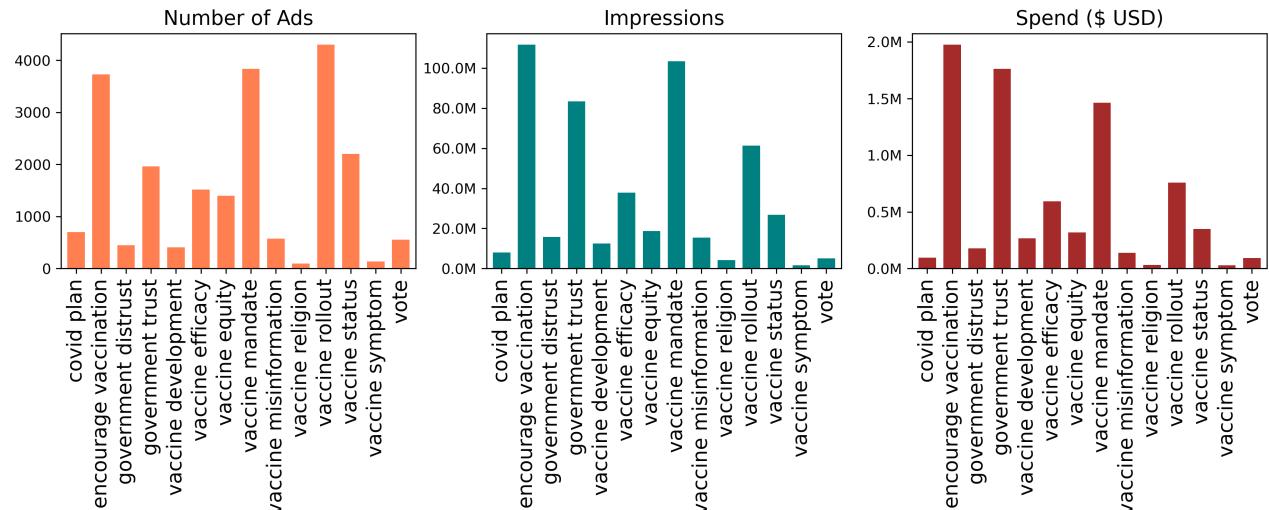
member today  
cannot look  
trust  
ke  
utmost  
court  
utmost  
could incur  
freedom  
biden  
win  
resource  
vaccinated  
hidden-administrati  
becoming  
fight  
mandat  
fight  
employee  
b

# Government trust

A word cloud visualization showing the frequency of words used by Biden in his speech. The most prominent words include 'today', 'biden', 'mandate', 'support', 'people', 'vaccination', 'free', 'clinic', 'appointment', 'hosting', 'schedule', 'pfizer', 'available', 'older', 'vaccinated', and 'rescue'.

## RQ1: What are the narratives of the messaging?

- Most popular theme **encourage vaccination** promoting vaccination to *protect their loved one, family, friends, and community* using **loyalty/betrayal** MF.
  - Next most popular (impressions) category: **vaccine mandate** featuring narratives focusing *Biden's vaccine mandate respective to freedom and tyranny*.
  - Second most popular (spend): **government trust** focusing on narratives *supporting Government's vaccination policy* emphasizing **care/harm** MF.



## Encourage vaccination

help vaccination loved one  
pandemic need public health community  
shot protect say got one  
click learn talk part one  
vaccinated vaccinated appointment  
getting people work  
today spread couple video question

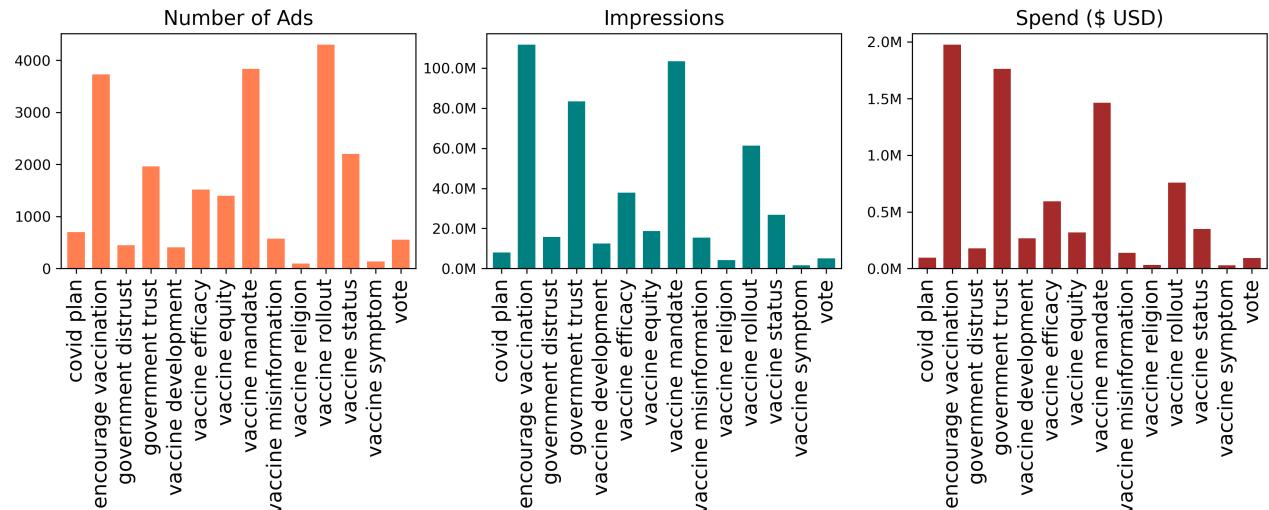
## Vaccine mandate

member today battle liberty center  
trust cannot least american work  
like fight could use governor  
fight freedom selling companies  
employment way news  
employee becoming stand  
resource hidden administration  
biden win president  
pandemic presidentamerica

# Government trust

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  - Second most popular (spend): **government trust** focusing on narratives *supporting Government's vaccination policy* emphasizing **care/harm** MF.
  - Sponsored ads mostly have **vaccine rollout** messaging theme focusing on *appointment availability, vaccine eligibility information from FDA and CDC*.



help vaccination loved one  
pandemic good public health community  
shot say family got one  
click learn talk school students  
vaccine can choose appointment  
vaccinated like spread zaffra  
getting people work  
today prevent spread couple video  
question

## Encourage vaccination

member today  
simply battle liberty  
trust cannot american  
make uta to beasts  
fight will companies  
emp loyee fight back  
freedom billion way  
emp biden win stand  
resource becoming  
adminstration

center talk  
governor today  
right american  
family rescue  
support school  
take president  
vaccinate  
pandemic people  
president american  
rescue plan  
vaccinate

## Vaccine mandate

# Vaccine rollout

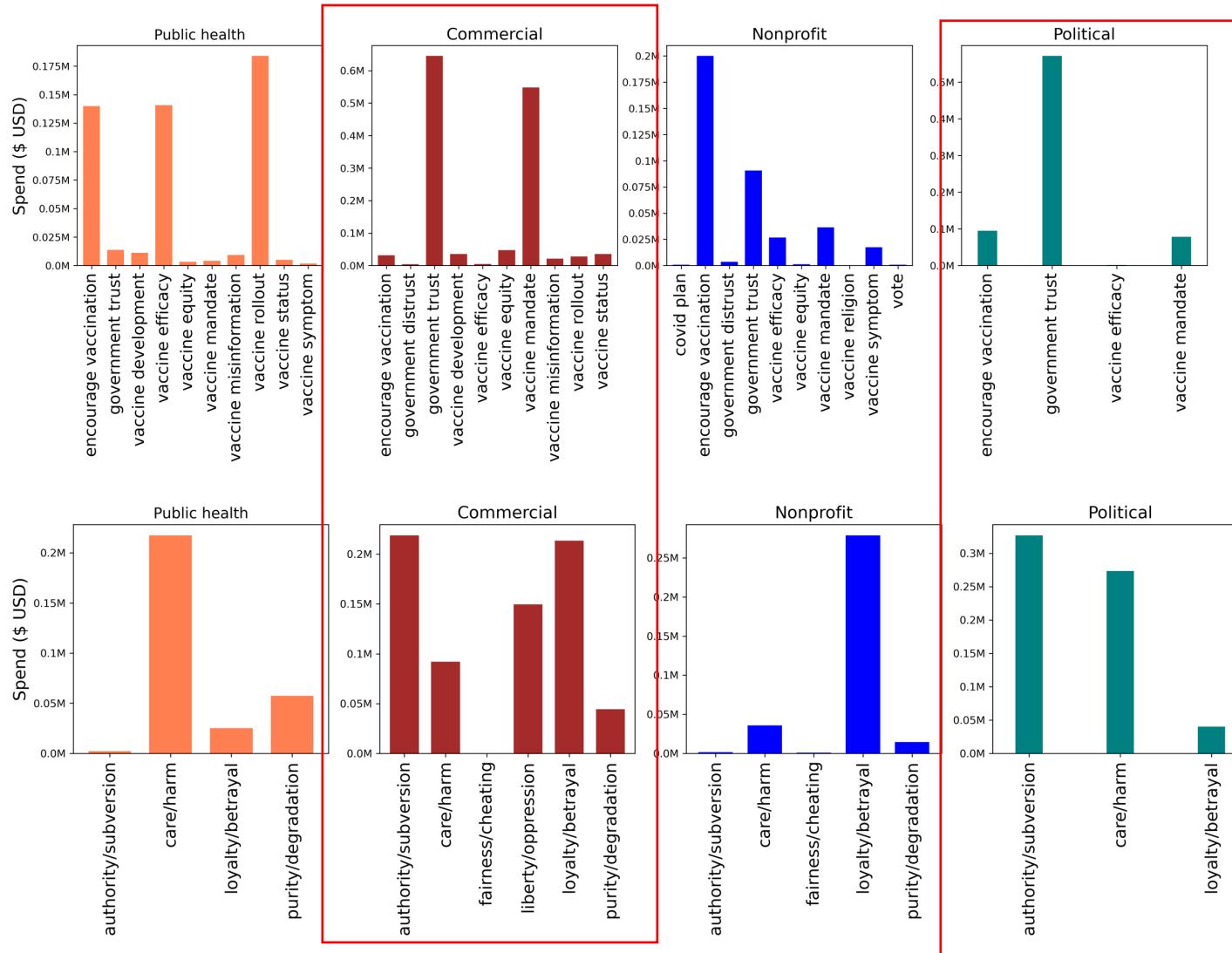
# RQ2: How does entity type fulfill messaging roles?

- Categorize funding entities into four types and select **top 5/category** based on **expenditure**.
  - Public health
  - Commercial
  - Nonprofit
  - Political

Type	Entity
Public health	Children's Health System of Texas
Public health	New York City Department of Health and Mental Hygiene
Public health	South Carolina Department of Health & Environmental Control
Public health	South Dakota Department of Health
Public health	Washington State Department of Health
Commercial	Pfizer Inc.
Commercial	ATTN: INC.
Commercial	Daily Wire
Commercial	BMO Harris Bank
Commercial	NEWSMAX MEDIA, INC.
Political	JB for Governor
Political	Kemp for Governor Inc
Political	Save America Joint Fundraising Committee
Political	Future Majority, Inc
Political	Terry for Virginia
Nonprofit	Turning Point USA, Inc.
Nonprofit	American Health Care Association and National Center for Assisted Living
Nonprofit	PICO California Action Fund
Nonprofit	Ad Council
Nonprofit	PROJECT HOPE

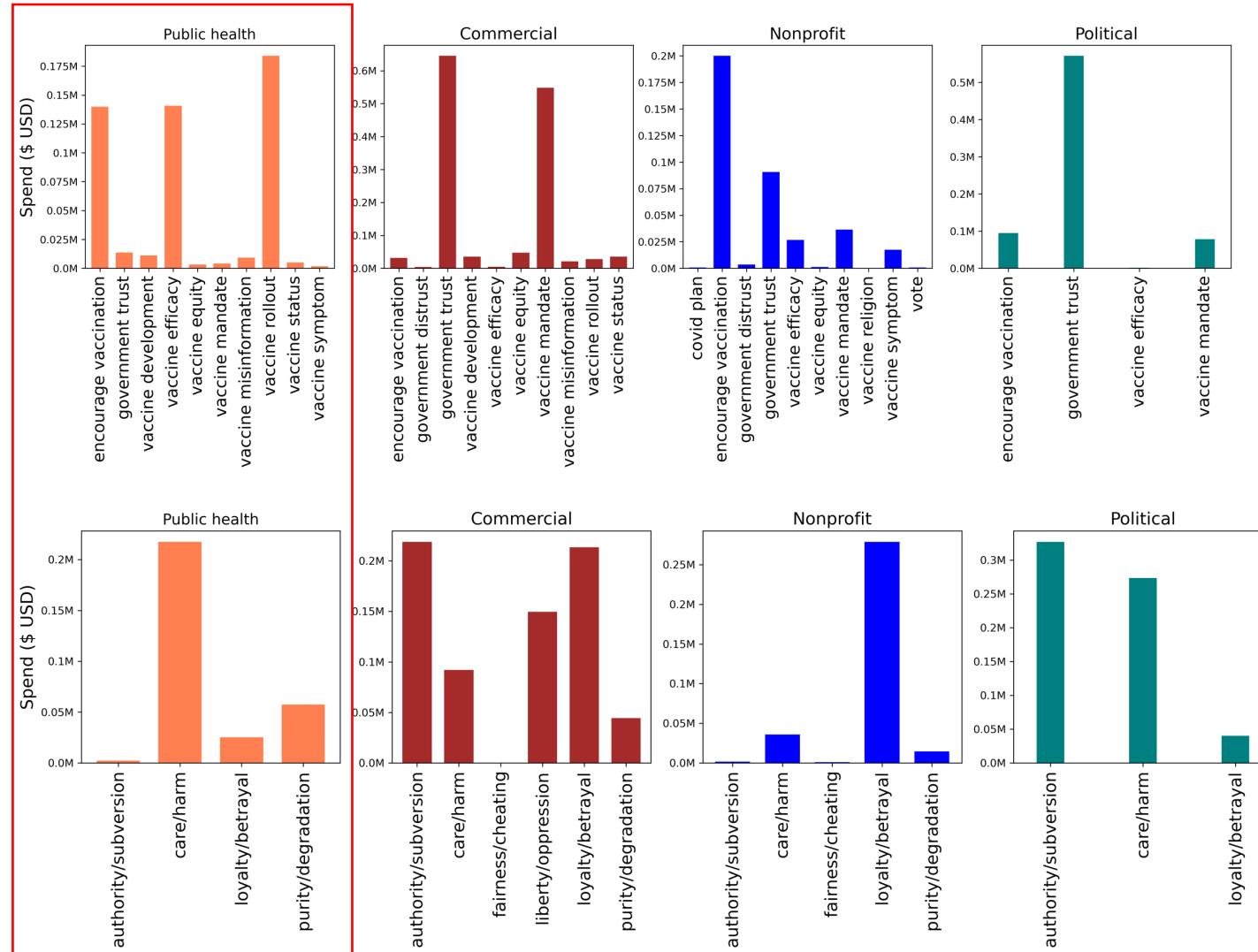
# RQ2: How does entity type fulfill messaging roles?

- High spend on **government trust** narratives comes mostly from **commercial** and **political** entities focusing on **authority/subversion** MF.



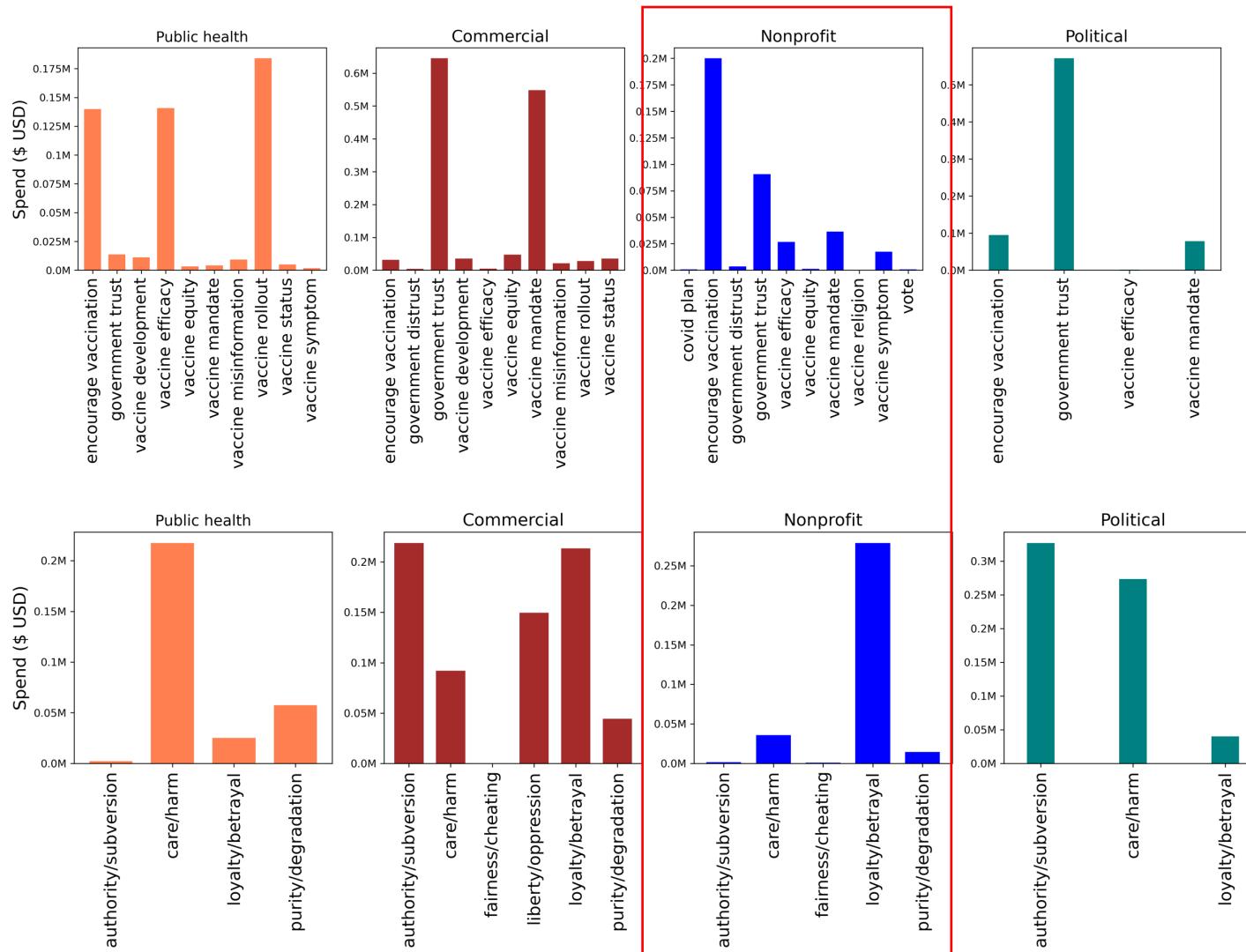
# RQ2: How does entity type fulfill messaging roles?

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- **Public health** entities spend more on **vaccine rollout** theme and **care/harm** MF.



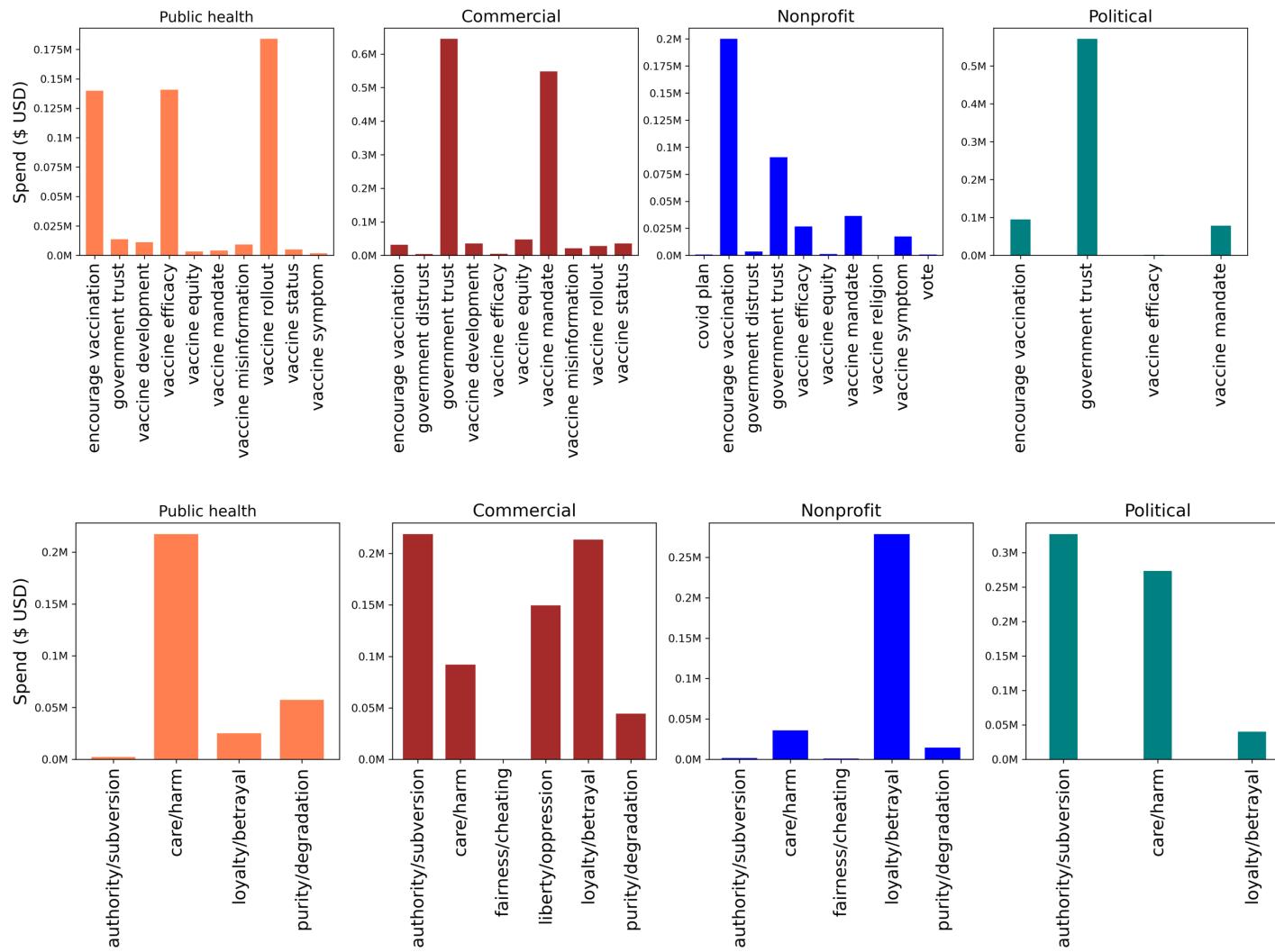
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- **Nonprofit** agency focus on **encourage vaccination** theme and **loyalty/betrayal** MF.



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- **Nonprofit** agency focus on **encourage vaccination** theme and **loyalty/betrayal** MF.
- Statistically significant (**p-value < 0.05**).



# RQ2: How does entity type fulfill messaging roles?

- **Messaging by Advertisers' Political View**
  - **16 political funding entities and views at [OpenSecrets.org](https://www.opensecrets.org).**

Liberal	Conservative
Friends for Kathy Hochul	North Carolina Republican Party
House Majority Forward	TEXANS FOR SENATOR JOHN CORNYN INC.
INDIVISIBLE ACTION	JIM JORDAN FOR CONGRESS
Alexandria Ocasio-Cortez for Congress	Friends of Matt Gaetz
Charlie Crist for Governor	RAND PAUL FOR US SENATE
Election Fund of Steven Fulop 2021	UNSILENCED MAJORITY
JAY CHEN FOR CONGRESS	Schmitt for Senate
Elicker 2021	Dr Scott Jensen for Governor

# RQ2: How does entity type fulfill messaging roles?

- **Messaging by Advertisers' Political View**
  - **16 political funding entities and views at [OpenSecrets.org](https://www.opensecrets.org).**
  - **Liberals mostly focus on encourage vaccination theme and care/harm MF.**

Liberal	Conservative
Friends for Kathy Hochul	North Carolina Republican Party
House Majority Forward	TEXANS FOR SENATOR JOHN CORNYN INC.
INDIVISIBLE ACTION	JIM JORDAN FOR CONGRESS
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Charlie Crist for Governor	RAND PAUL FOR US SENATE
Election Fund of Steven Fulop 2021	UNSILENCED MAJORITY
JAY CHEN FOR CONGRESS	Schmitt for Senate
Elicker 2021	Dr Scott Jensen for Governor

# RQ2: How does entity type fulfill messaging roles?

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  - **16 political** funding entities and views at [OpenSecrets.org](https://www.opensecrets.org).
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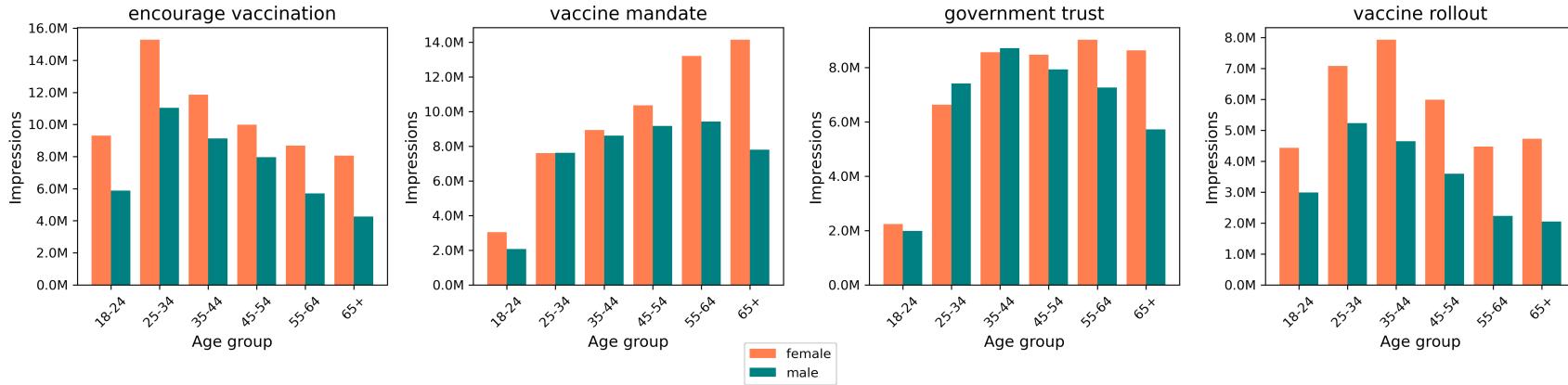
Liberal	Conservative
Friends for Kathy Hochul House Majority Forward INDIVISIBLE ACTION Alexandria Ocasio-Cortez for Congress Charlie Crist for Governor Election Fund of Steven Fulop 2021 JAY CHEN FOR CONGRESS Elicker 2021	North Carolina Republican Party TEXANS FOR SENATOR JOHN CORNYN INC. JIM JORDAN FOR CONGRESS Friends of Matt Gaetz RAND PAUL FOR US SENATE UNSILENCED MAJORITY Schmitt for Senate Dr Scott Jensen for Governor

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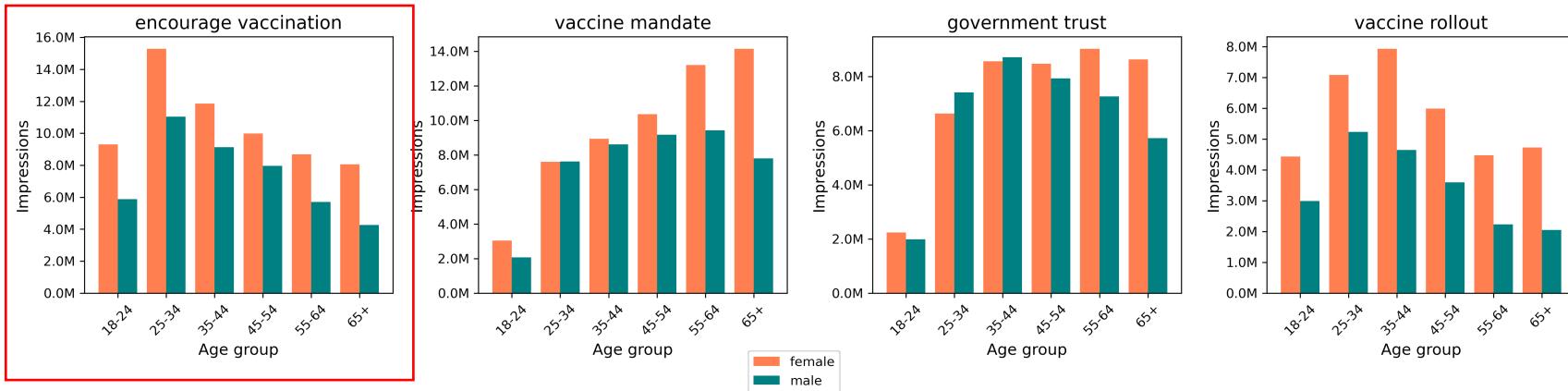
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  - Statistically significant (**p-value < 0.05**).

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# RQ3: Which demographics and geographic are reached by the advertisers and their messages?

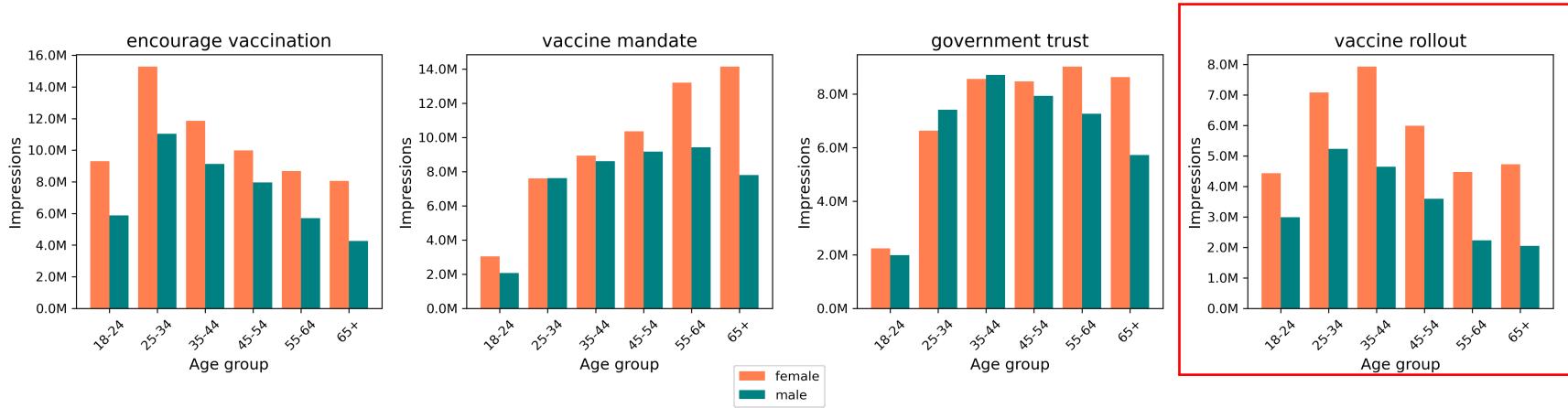


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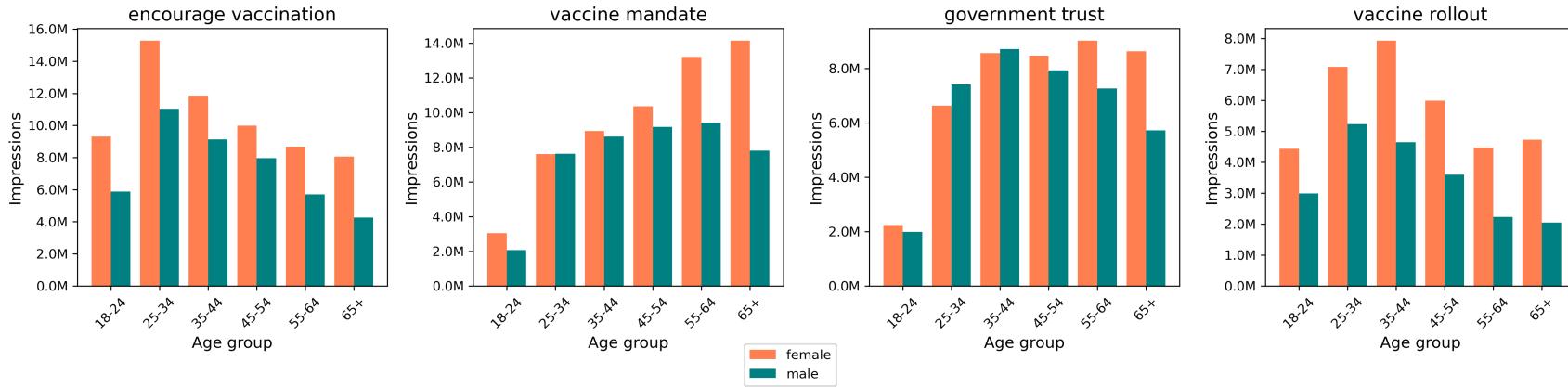
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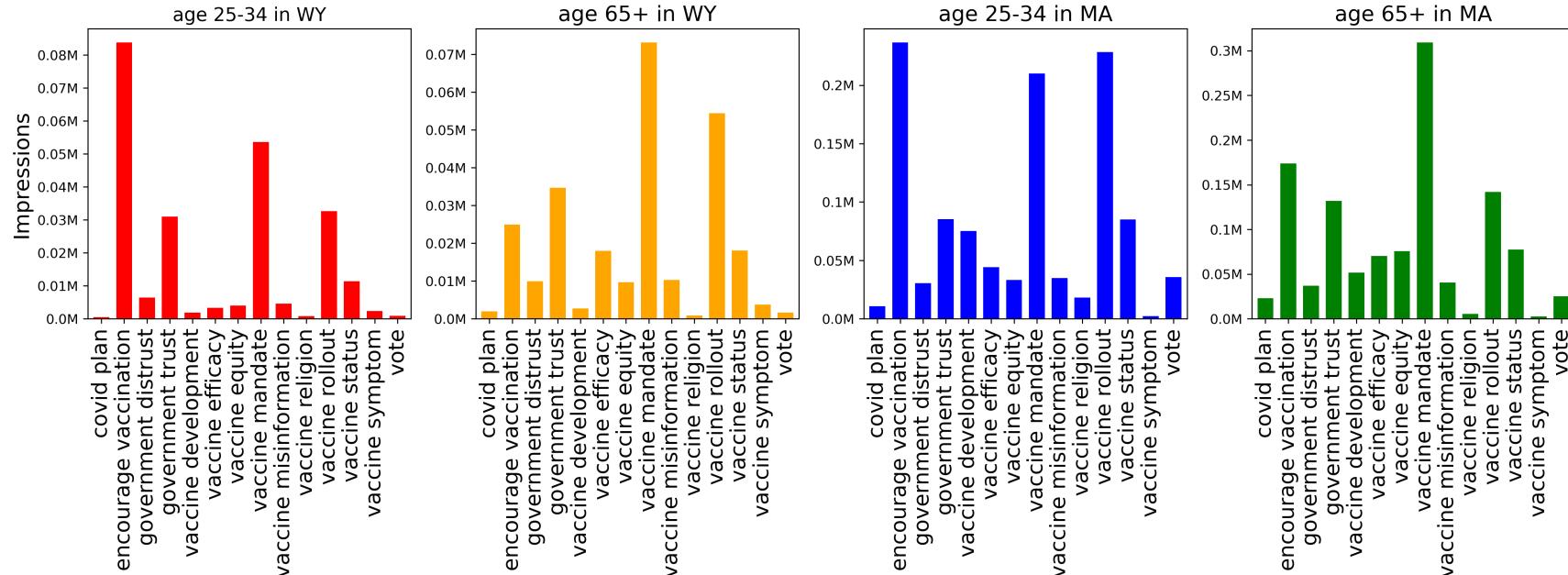
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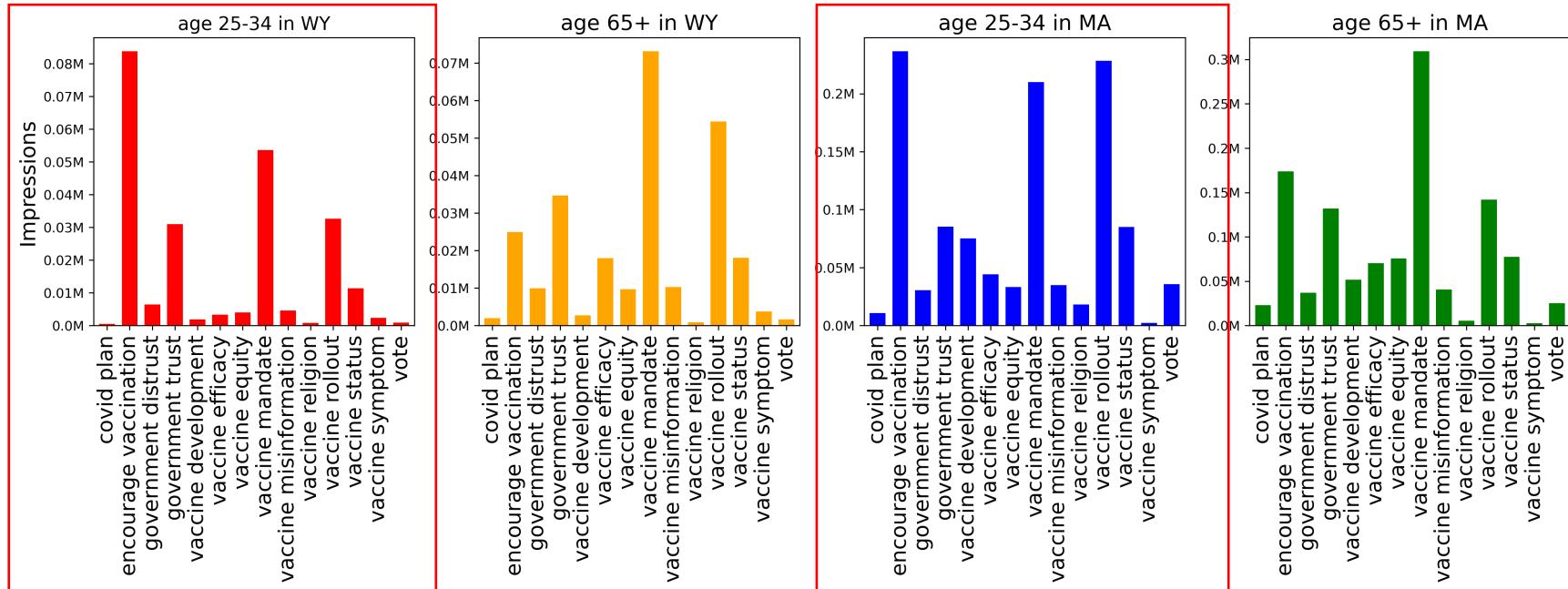


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- Highly statistically significant (**p-value < 0.01**).

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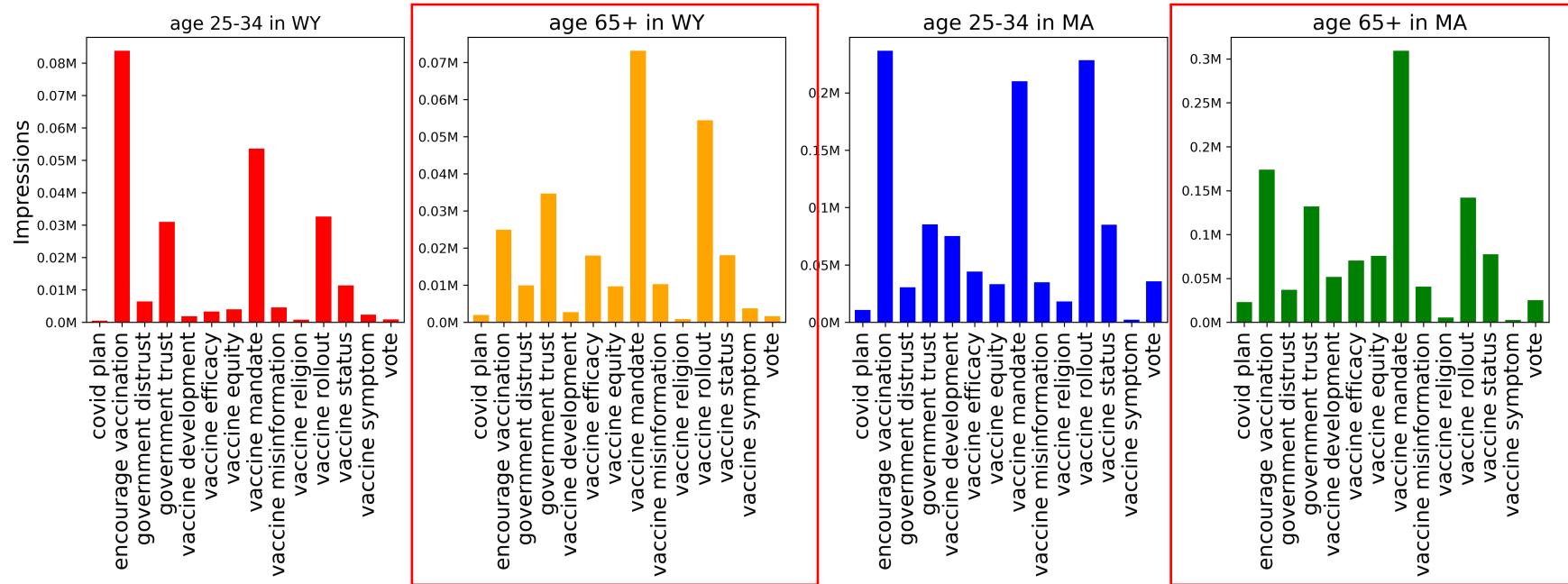


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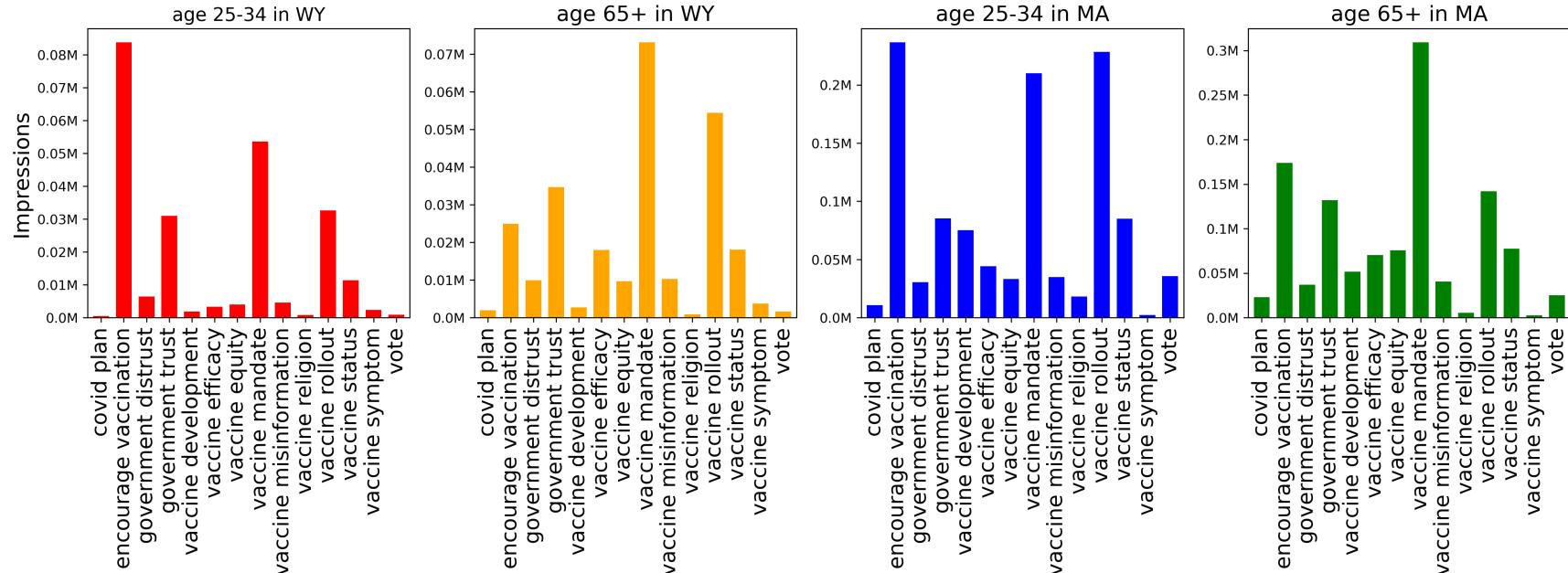
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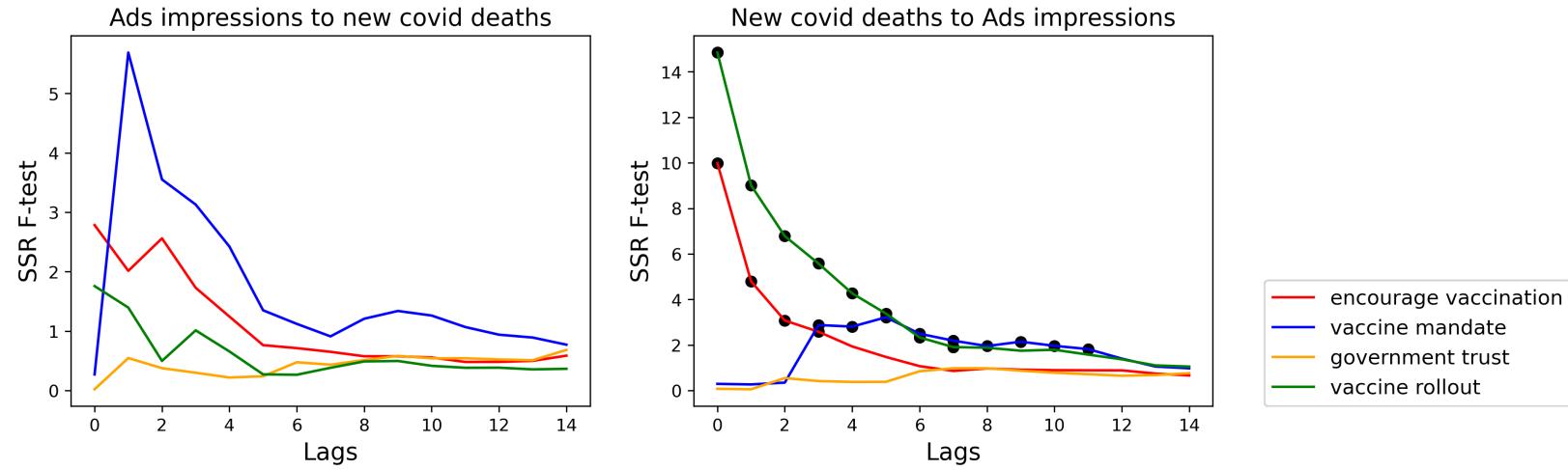
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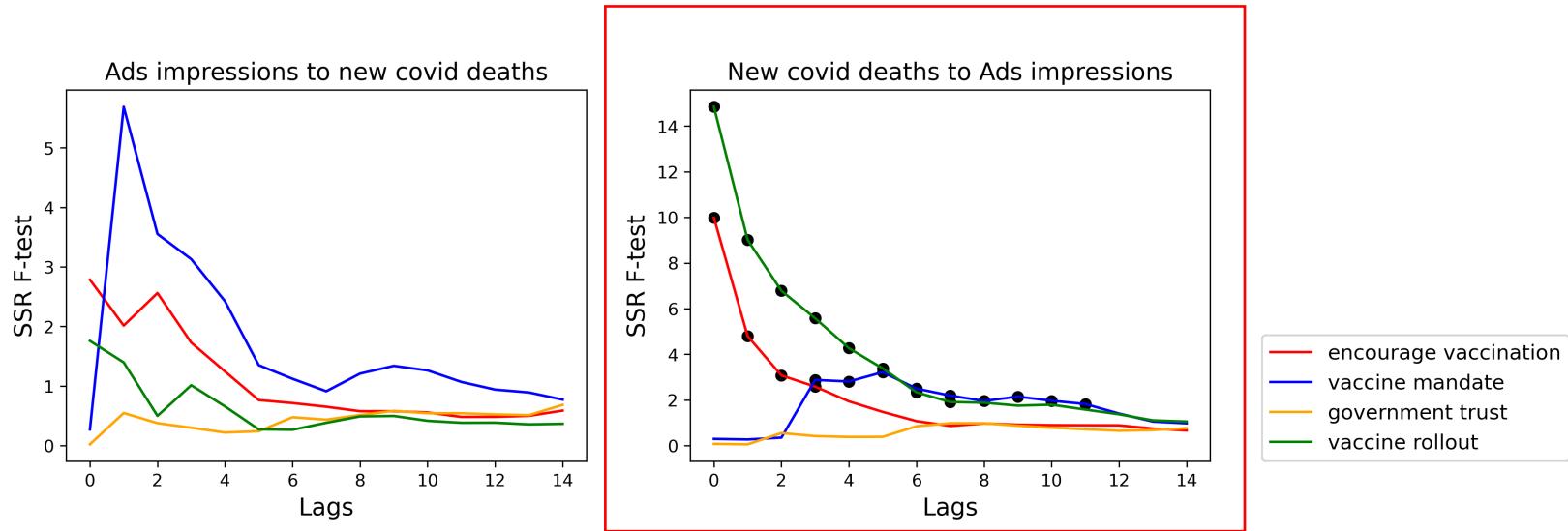


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# RQ4: Do ads follow current covid status?



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- Significant F-test for the hypothesis of **number of new COVID death per day *Granger causes* ad impressions** on specific theme (**p-value < 0.05**).

# Key Takeaways

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- As we make our dataset available to the community, we hope the **advertising domain will become a crucial part of public discourse on public health**.

# THANK YOU 😊

Slide: [https://tunazislam.github.io/files/IEEEBigData2022\\_CovidFBad.pdf](https://tunazislam.github.io/files/IEEEBigData2022_CovidFBad.pdf)

## Questions?

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