YOU ARE WHAT YOU TWEET: ANALYZING TWITTER FOR PUBLIC HEALTH

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RESEARCH QUESTION

- Is there a public health signal that can be detected within the chatter of Twitter?
- If so, what can we do with that signal?

MINING HEALTH TRENDS

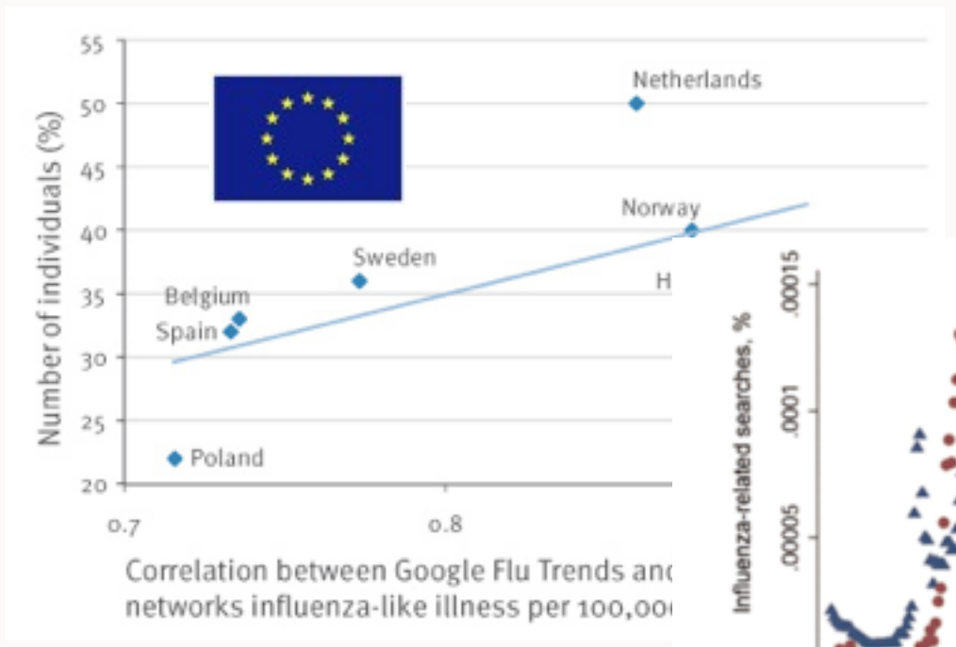
- Google search query: `flu medicine`
  - It's likely this person has the flu
- google.org Flu Trends aggregate and correlate queries to predict flu activity

Ginsberg, Mohebbi, Patel, Brammer, Smolinski, Brilliant. Detecting influenza epidemics using search engine query data. *Nature* Vol 457, 19 February 2009,

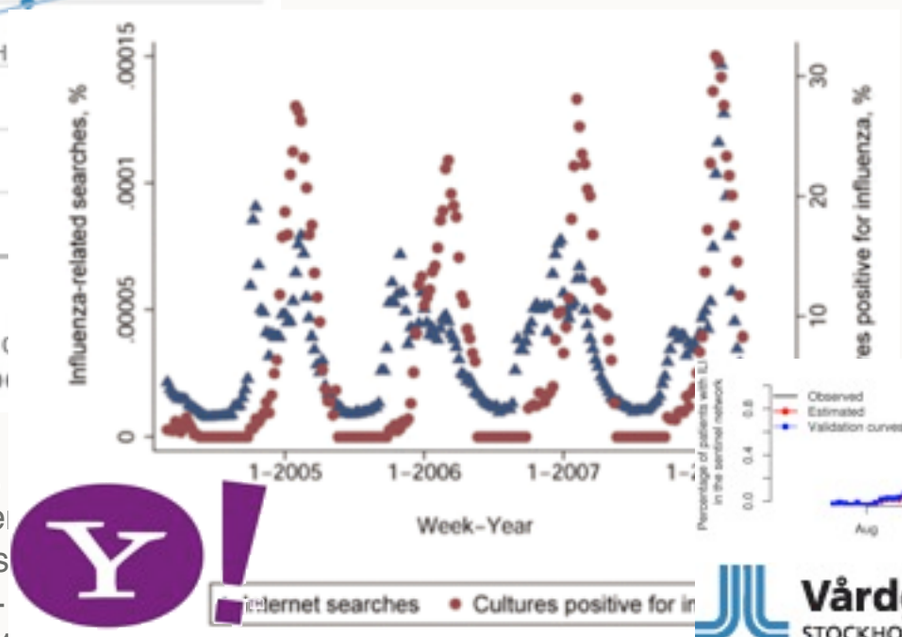
- Similar results can be replicated with Twitter messages in place of search queries
  - Tweets also contain more info than search queries

Culotta, Aron. Towards detecting influenza epidemics by analyzing Twitter messages. *KDD Workshop on Social Media Analytics*. 2010.

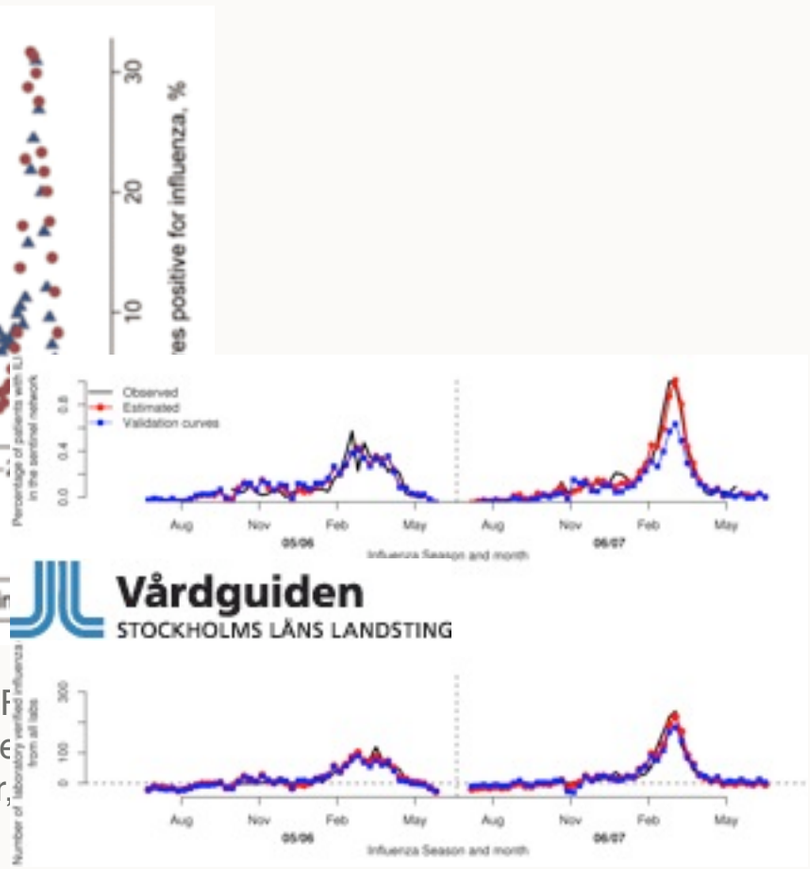
RELATED WORK



A Valdivia, J Lopez-Alcalde, M Vicente, Ruiz, and M Ordobas. Monitoring influe europe with google flu trends: comparis findings of sentinel physician networks- 2009-10. *Euro Surveill*, 15(29), July 201



PM Polgreen, Y Chen, DM Pennock, and F Using internet searches for influenza surve *Clin Infect Dis.*, 47(11):1443–8, December,



Anette Hulth, Gustaf Rydevik, and Annika Linde. Web queries as a source for syndromic surveillance. *PLoS ONE*, 4(2):e4378, 02, 2009.

RELATED WORK

- More Twitter papers in 2011:

Achrekar, Harshavardhan; Gandhe, Avinash; Lazarus, Ross; Ssu-Hsin Yu; Liu, Benyuan. Predicting Flu Trends using Twitter. 2011.

Prier, Smith, Giraud-Carrier, Hanson. Identifying health related topics on twitter: an exploration of tobacco related tweets as a test topic. 2011.

Eiji Aramaki, Sachiko Maskawa and Mizuki Morita: Twitter Catches The Flu: Detecting Influenza Epidemics using Twitter,*Conference on Empirical Methods in Natural Language Processing (EMNLP2011)* , 2011.

A GENERAL APPROACH

- Most previous studies were very focused
  - One disease of interest
  - Supervised approaches with training data
- Our assumption: don't know a priori what to look for
  - General approach to look for many diseases
  - Use unsupervised or semi-supervised models

PART 1: MODELING HEALTH TWEETS

- Not all Tweets actually talk about health

> I FEEL LIKE I'M GOING TO DIE OF BIEBER FEVER. NO JOKE.

> Web design class gives me a huge headache everytime.

- Step 1: find health related tweets
  - Method: supervised machine learning
- Step 2: group tweets by disease/ailment
  - Method: unsupervised topic models

TRAINING CORPUS

- Trained SVM classifier on 5,128 hand labeled tweets
  - Cross-validation precision: 90%
- Corpus: 2B tweets from May 2009 to October 2010

Keyword filter

Classifier

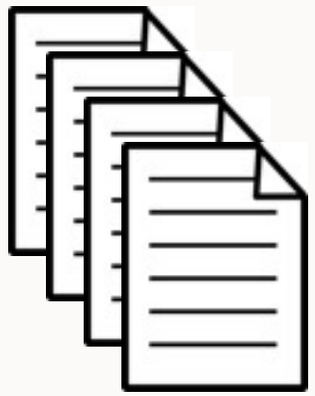
2 billion

11.7 million

1.63 million Health Tweets

CATEGORIZING TWEETS

- Now we have a set of tweets we know are about health



- Can we group them by ailment?
  - Solution: structured topic models
  - Use symptom/treatment structure to separate illness text from other text

UNSUPERVISED TOPIC MODELS

- Topic Models: a popular tool for modeling corpora
  - Bayesian probabilistic model for generating text

Blei, D.; Ng, A.; and Jordan, M. 2003. Latent dirichlet allocation. Journal of Machine Learning Research (JMLR) 3.

- Basic idea:
  - Each document is a distribution over topics
  - Each topic is a distribution over words
  - Infer these distributions automatically through posterior inference methods -> unsupervised

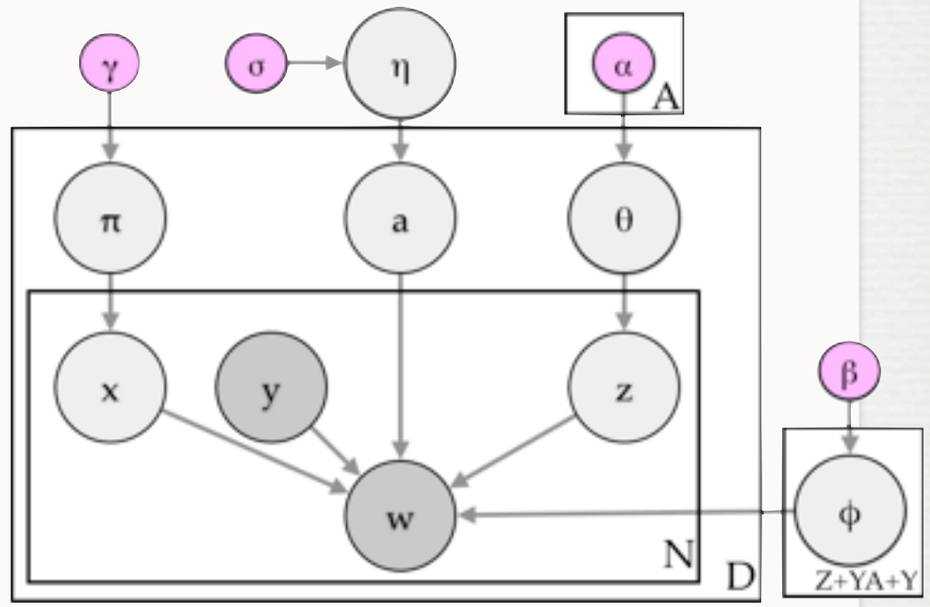
A MODEL FOR HEALTH IN TWITTER

- Each tweet is about an “ailment” (medical condition)
- Each word in a tweet comes from one of two sources:
  - General topics or background noise (not about health)
  - Ailment words: broken down into three facets (“aspects”)
    - General words, symptoms, treatments
      - Symptoms and treatments identified based on scraped list

Flu: runny nose, headache, advil!!!!!! home sick watching TV

ATAM

- **Ailment Topic Aspect Model (ATAM)**
- For each tweet (to **D**):
  - Select an ailment **a** from a distribution **η**
  - Select a topic distribution from **θ**
  - Select a switching distribution **π**
- For each word (to **N**):
  - Select switching variable **x** from **π**
  - If x == topic:
    - Generate topic **z** from **θ** and then word **w** from ϕ_z
  - If x == ailment:
    - Observe **y** and generate word **w** from $\phi_{a,y}$



LABELING AILMENTS

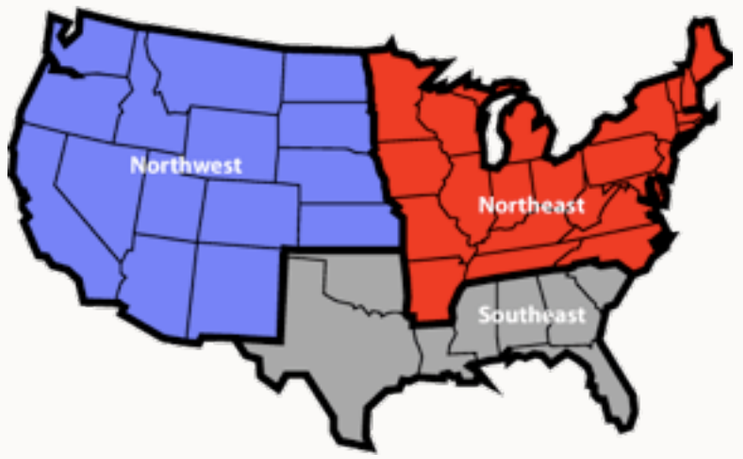
- Inference: Gibbs sampling (see paper)
- Two annotators labeled model output (based on top 20 ailment words) with ailment name or as "incoherent"
  - Each ailment has top 20 general wo
    words, treatment words
- Agreed on labels for 15/20 ailments
  - Focused on these 15 in further

AILMENTS: EXAMPLE OUTPUT

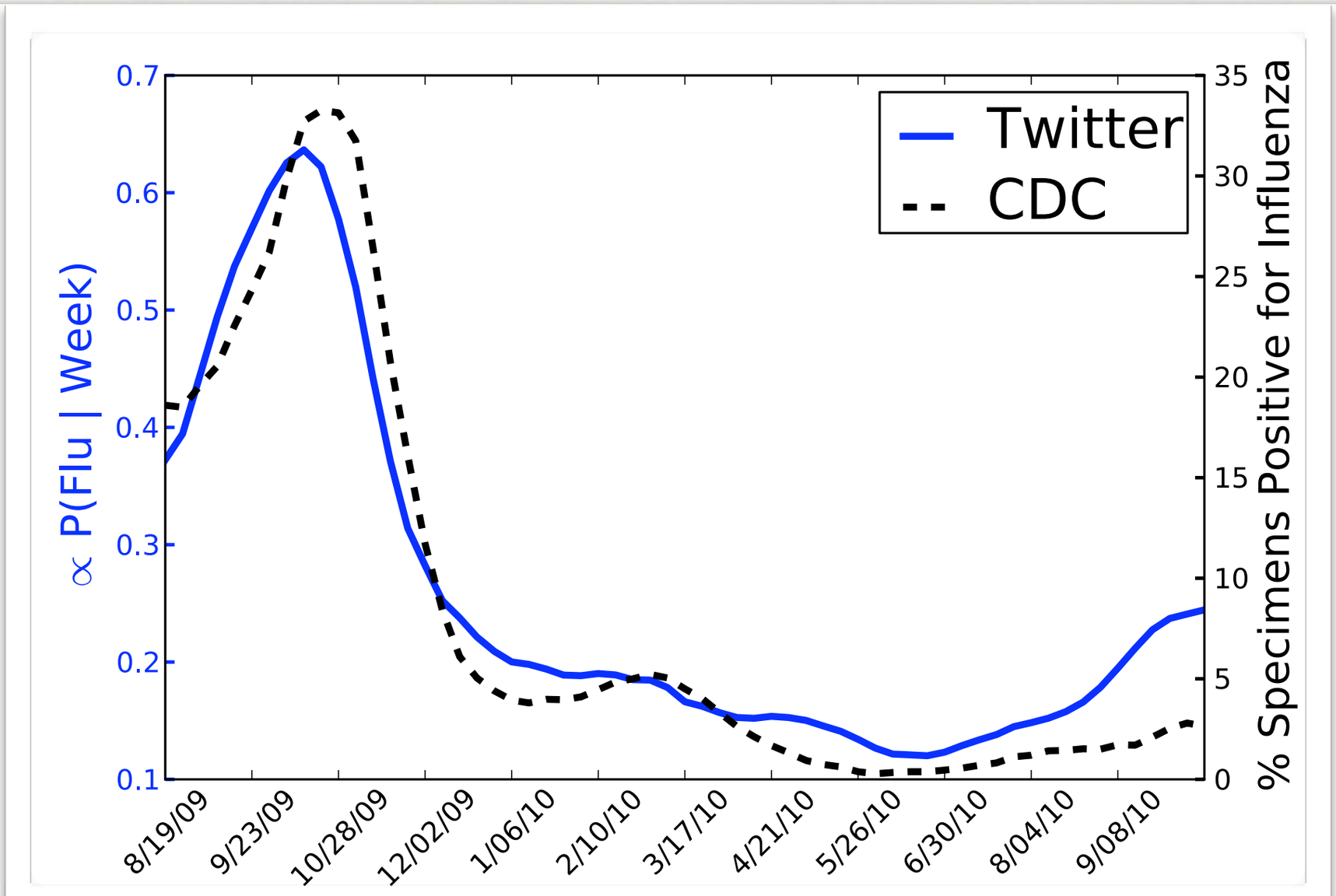
Ailment	Allergies	Aches/Pains	Dental
General Words	allergies stop eyes allergic	body head need hurts	meds killers dentist teeth
Symptoms	sneezing cold coughing	pain aches stomach	pain toothache sore
Treatments	medicine benadryl claritin	massage “hot bath” ibuprofen	braces surgery antibiotics

PART 2: ANALYZING AILMENTS

- We now have groups of tweets categorized by ailment
- We can analyze each ailment
  - Trends over time
  - Trends across geography
  - Deeper symptom and treatment analysis



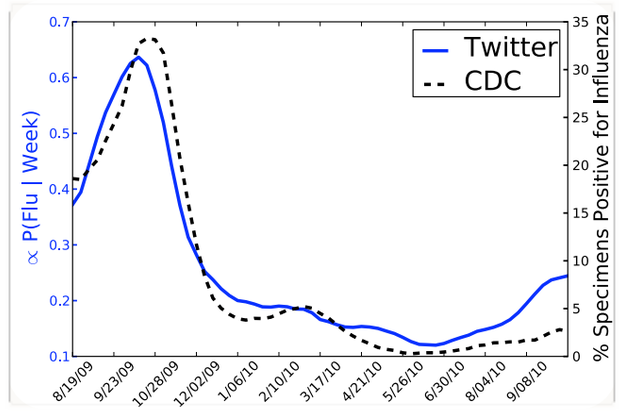
FLU TRENDS REDUX



- Correlation coefficient: 0.958

RICHER MODEL

- Previous work focused on influenza surveillance
- We have a richer model!

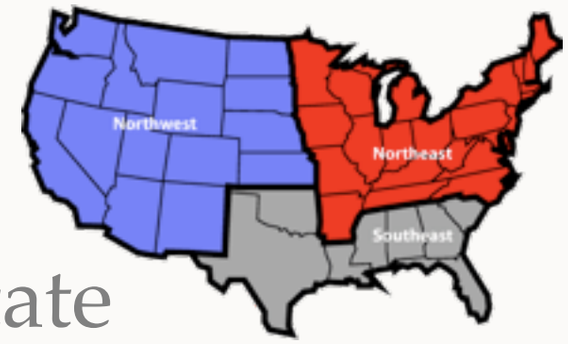


Allergies	Infections
Aches/Pains	Influenza
Cancer	Insomnia
Common Cold	Obesity
Dental	Physical Injuries
Depression	Respiratory Illness
Exercise	Skin Problems
Headaches	

What other public health information can we learn from Twitter?

GEOGRAPHIC SURVEILLANCE

- Track ailments by time and location



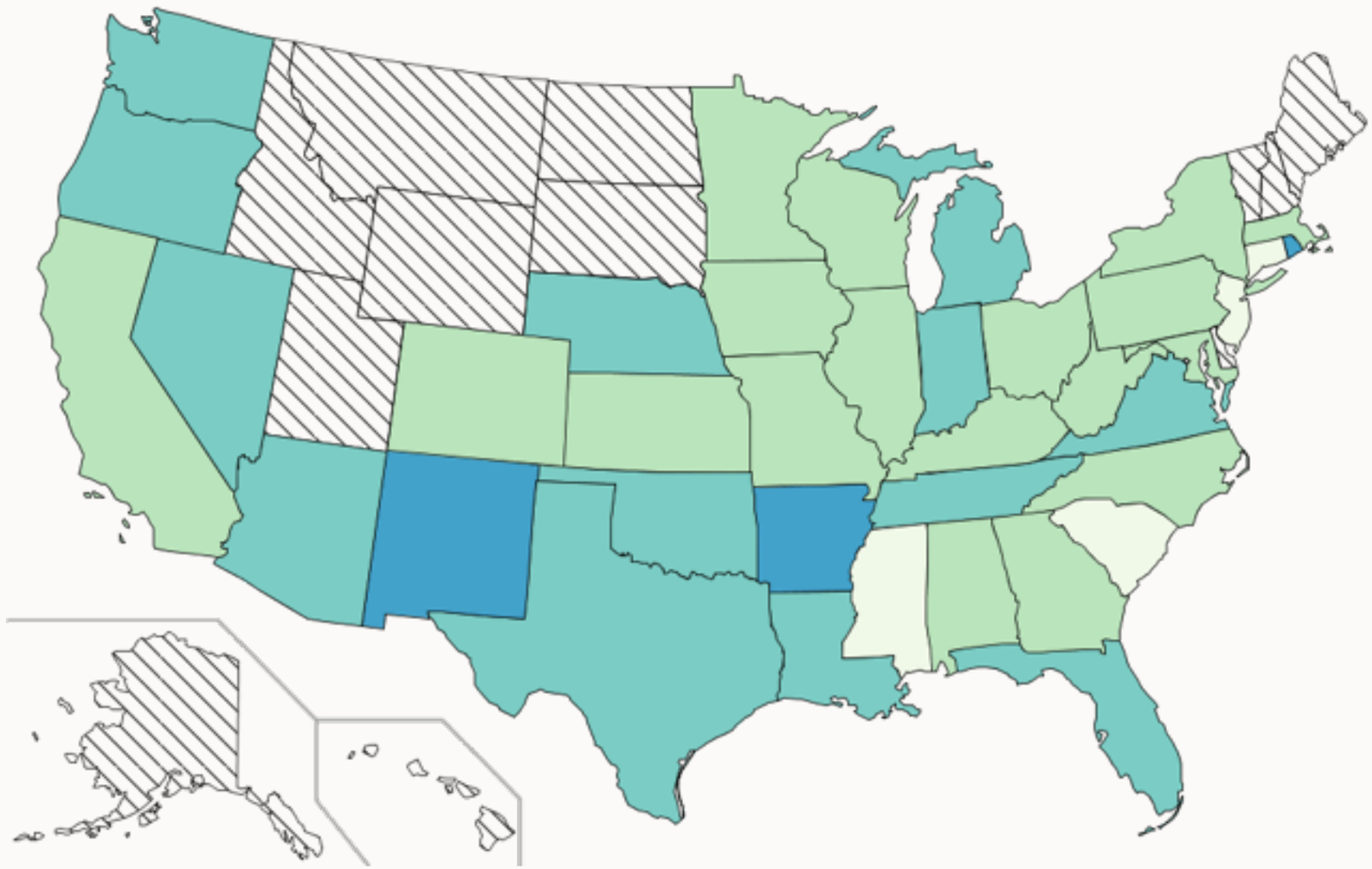
  - Compute ailment per capita in each state for each month

    - Determine state for 200,000 tweets with simple keyword filtering

- Seasonal allergies

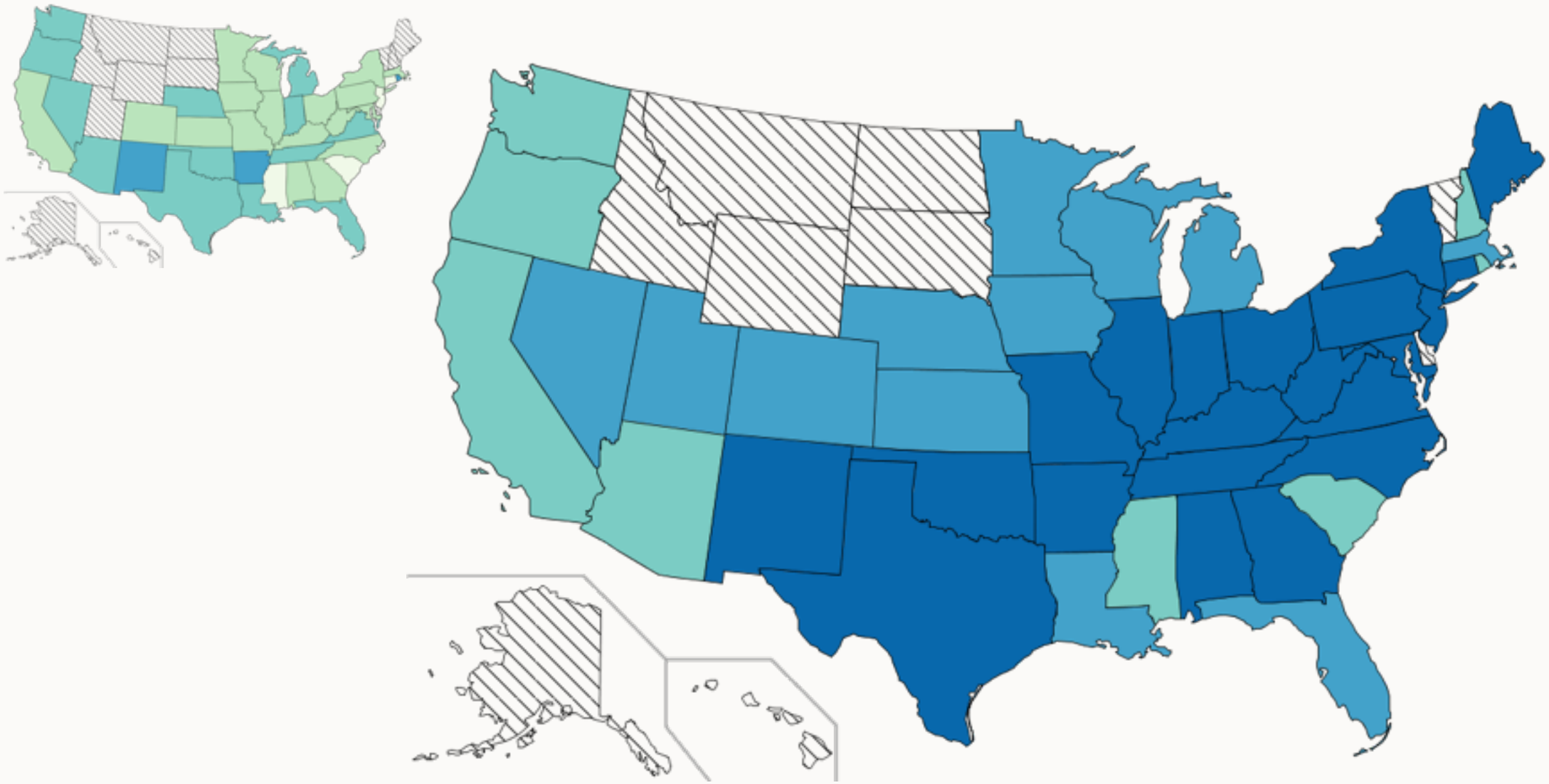
  - Allergy season starts in different months in different regions

ALLERGIES



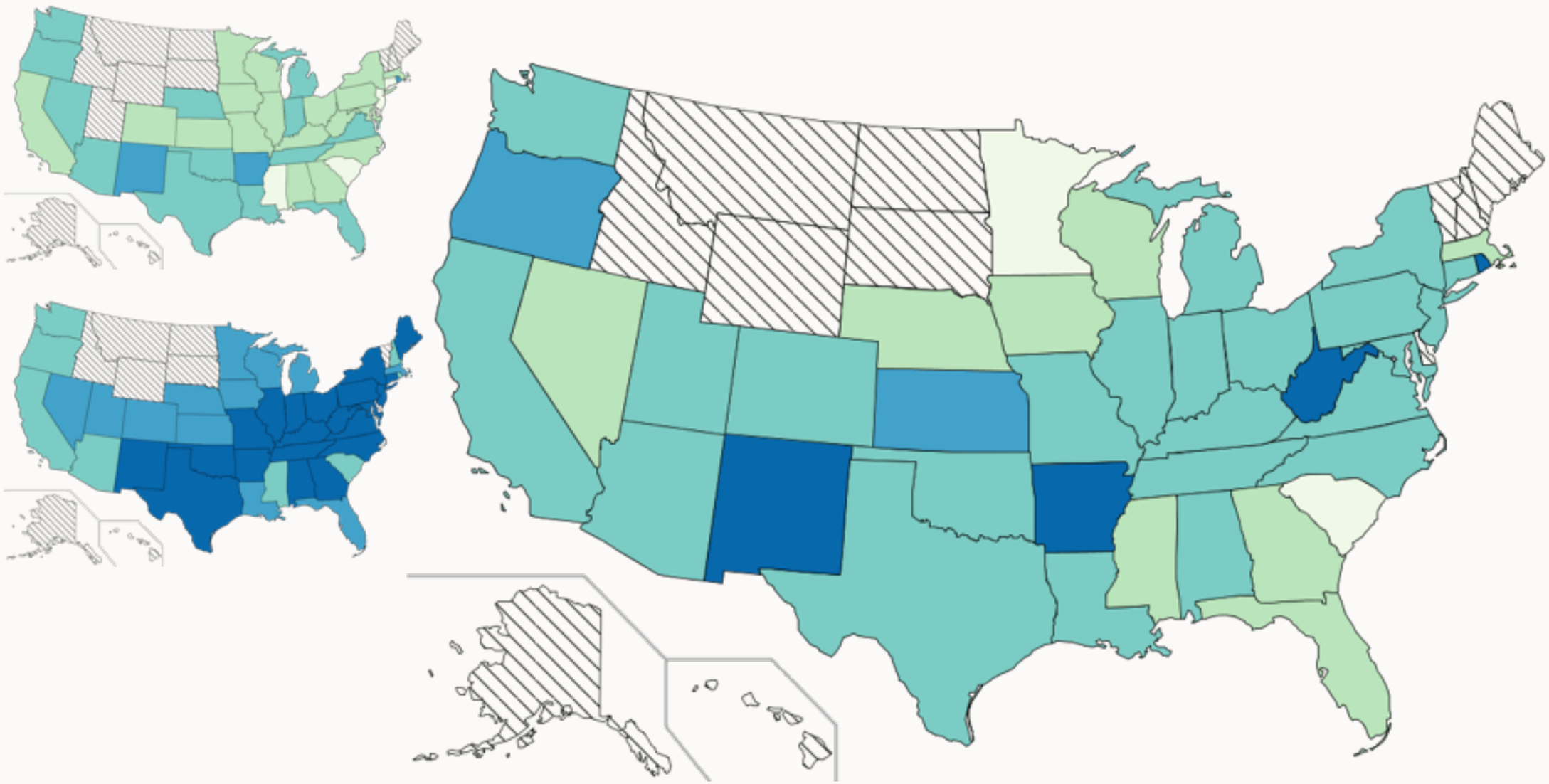
February

ALLERGIES



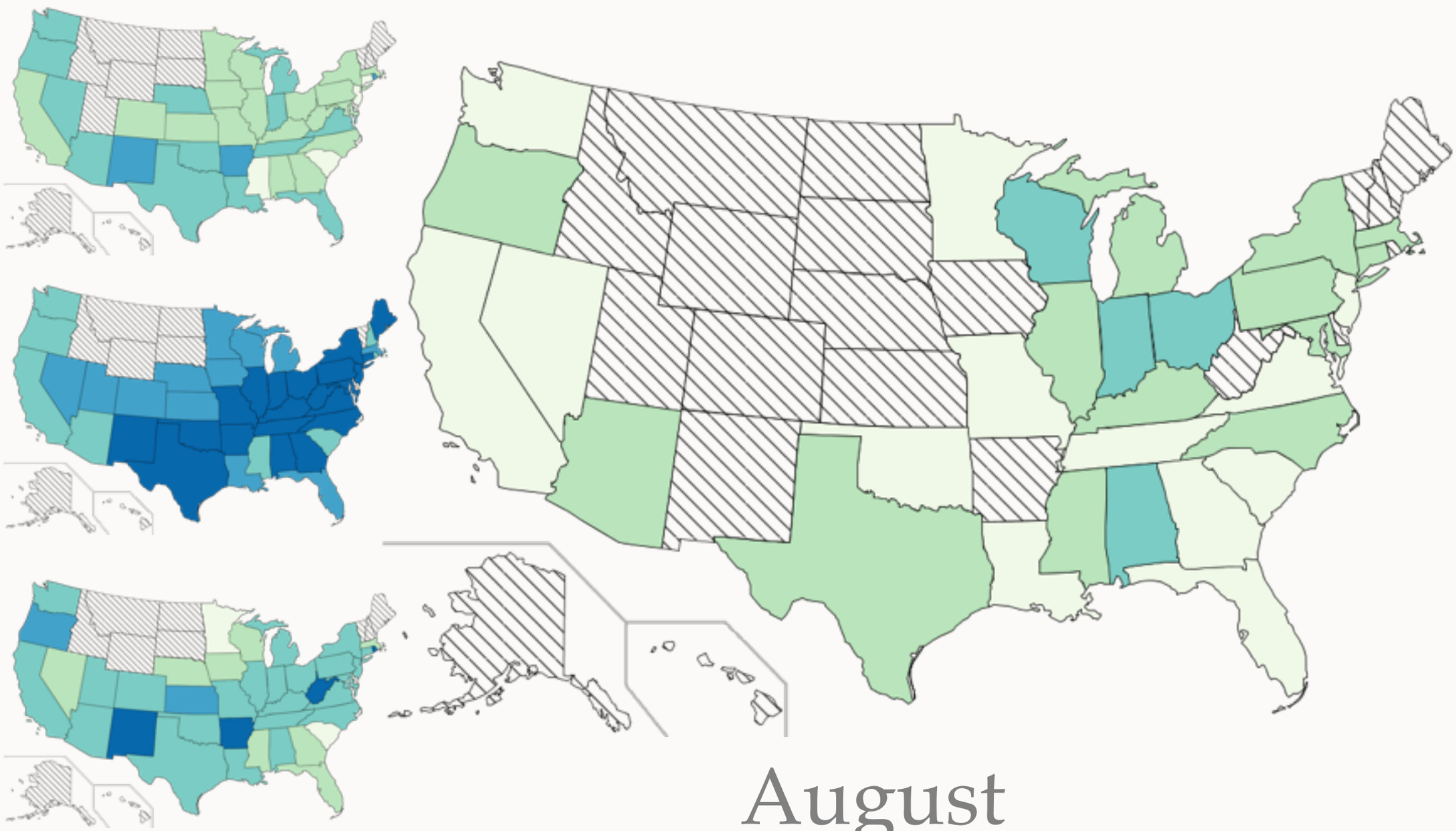
April

ALLERGIES



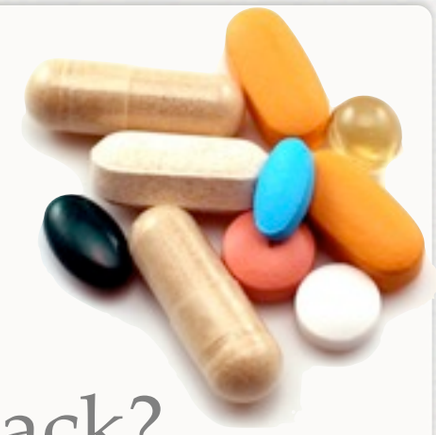
June

ALLERGIES



August

SELF-REPORTED MEDICATION USAGE



- We have questions about how populations are medicating
- Since many patients self-medicate, how to track?

> Whhhhhhat?!?!?! I don't always **sleep**! But I did have a drug-induced slumber last night. I told you Benadryl is my friend

> Didn't take a benadryl last night so therefore my allergies f****** up my sleep. I was coughing and blowing my nose all night :-(

- What ailments are most associated with **treatments**?

PAIN RELIEF MEDS

Medicine	Entropy	Most Common Ailments
tylenol	1.57	Headache (39%), Insomnia (30%), Cold (9%)
ibuprofen	1.54	Headache (37%), Dental (21%), Aches (17%)
advil	1.08	Headache (61%), Cold (6%), Dental (5%)
asprin	1.04	Headache (69%), Insomnia (10%), Aches (10%)
vicodin	1.33	Dental (61%), Injuries (11%), Headache (10%)
codeine	1.94	Cold (25%), Dental (19%), Headache (17%)
morphine	1.17	Dental (59%), Infection (22%), Aches (9%)

ALLERGY MEDS

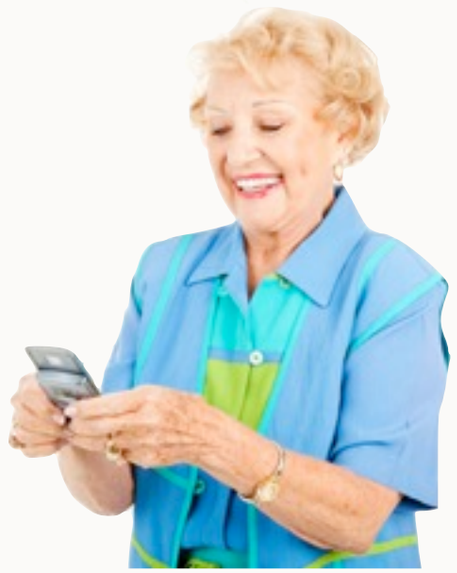
Medicine	Entropy	Most Common Ailments
benadryl	1.24	Allergies (64%), Skin (13%), Insomnia (12%)
claritin	0.54	Allergies (88%), Headache (5%)
zyrtec	0.49	Allergies (90%)
sudafed	1.61	Allergies (39%), Cold (21%), Headache (20%)

OTHER ANALYSES

- More experiments in the paper
- We look at symptoms in addition to treatments
- We find correlations between ailments and other known factors
  - Spoiler alert: cancer is correlated with tobacco rates

LOOKING FORWARD

- User population
  - Most users are in the US
  - Young population
    - Many under 35
    - Less than 2% are older than 65



- Privacy
  - Limits to what people will share
    - Ex. STD

@maikel3000
Maikel O'Hanlon

U can find healthiness in Twitter. gigaom.com/2011/07/07/can... Just not while having ur nose in ur mobile phone while driving or crossing street

11 Jul via Tweet Button

@ej_butler
Ed Butler

Some resourceful researchers are figuring out ways to mine Twitter data to find health trends http://n.pr/rlfRDy /via @NPRHealth #hcmsanz

@afsh_ahmed
Afshan

Twitter: essential research tool or means 2 make researchers jus plain lazy? Researchers take US temperature via Twitter bbc.co.uk/news/technolog...

@SSinSF
Scott Shadiow

You never cease to amaze me @Twitter... RT @NPRHealth Twitter Provides A Trove Of Health Trends n.pr/oI7WXr

@ashdonaldson
Ash Donaldson

Perfect storm for misinfo: HuffPo article about comp scientists studying health, reported by Fox & Daily Mail huff.to/pS1ylB

8 Jul via Echofon

@heekeuri
Heekmah(dictatedby希)

"Mark Dredze and Michael J. Paul fed 2 billion public tweets posted between May 2009 and October 2010 into computers" WE ARE BEING WATCHED