UDERSTANDING POTENTIAL CATTLE CONTRIBUTION TO LEAFY GREEN OUTBREAKS

A scoping review of the literature, outbreak investigations and digital media

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Funded by
the Beef Checkoff

Introduction

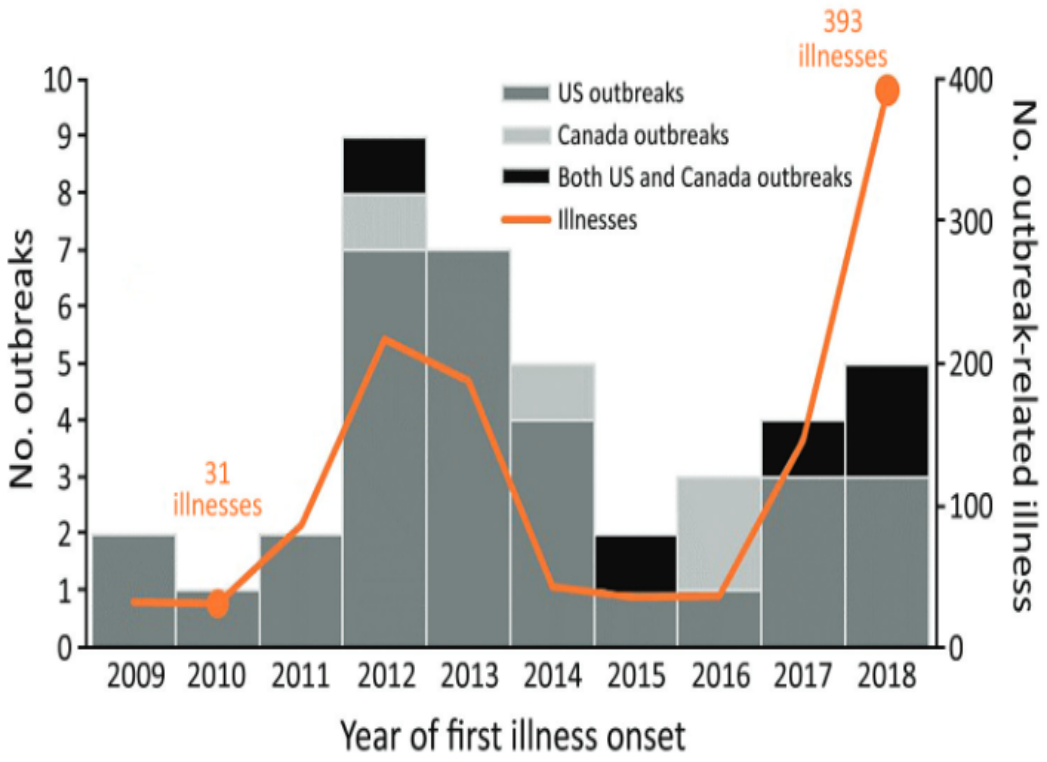


Figure 1. Number of Shiga toxin–producing *Escherichia coli* outbreaks (n = 40) linked to leafy greens in the United States, Canada, or both countries, and all outbreak-related illnesses (n = 1,212), by year of first illness onset, 2009–2018.

Marshall et al., 2010, Emerg. Infect. Dis., 26(10)

Leafy greens STEC outbreaks

- Between 2009-2018
  - 40 outbreaks of STEC infections
  - 18 confirmed association with leafy greens
  - 22 suspected

Research Question

“What is the current scope of the literature, government reports and social media on the potential cattle contribution to outbreaks associated to leafy green produced nearby or adjacent lands?”

Specific research questions:

1. Is there evidence that cattle production contributes to the contamination of leafy greens with foodborne pathogens?
2. What are the proposed or proven mechanisms of transmission between cattle and produce?
3. Does consumption of leafy greens produced near cattle feedlots increase risks of foodborne disease?
4. What is the extent of the gap between official risk communication and popular press and social media?
5. What are the knowledge gaps in mechanisms of transmission from cattle feedlots to produce fields and their contribution to foodborne diseases.

Review Protocol

- PICo Framework (Population, Phenomena of Interest, Context)

Population	Leafy greens (and other produce)
Phenomenon of Interest	Contribution of cattle to leafy green outbreaks.
Context	Produce farming nearby or adjacent to cattle production areas.

Scientific articles

Government reports

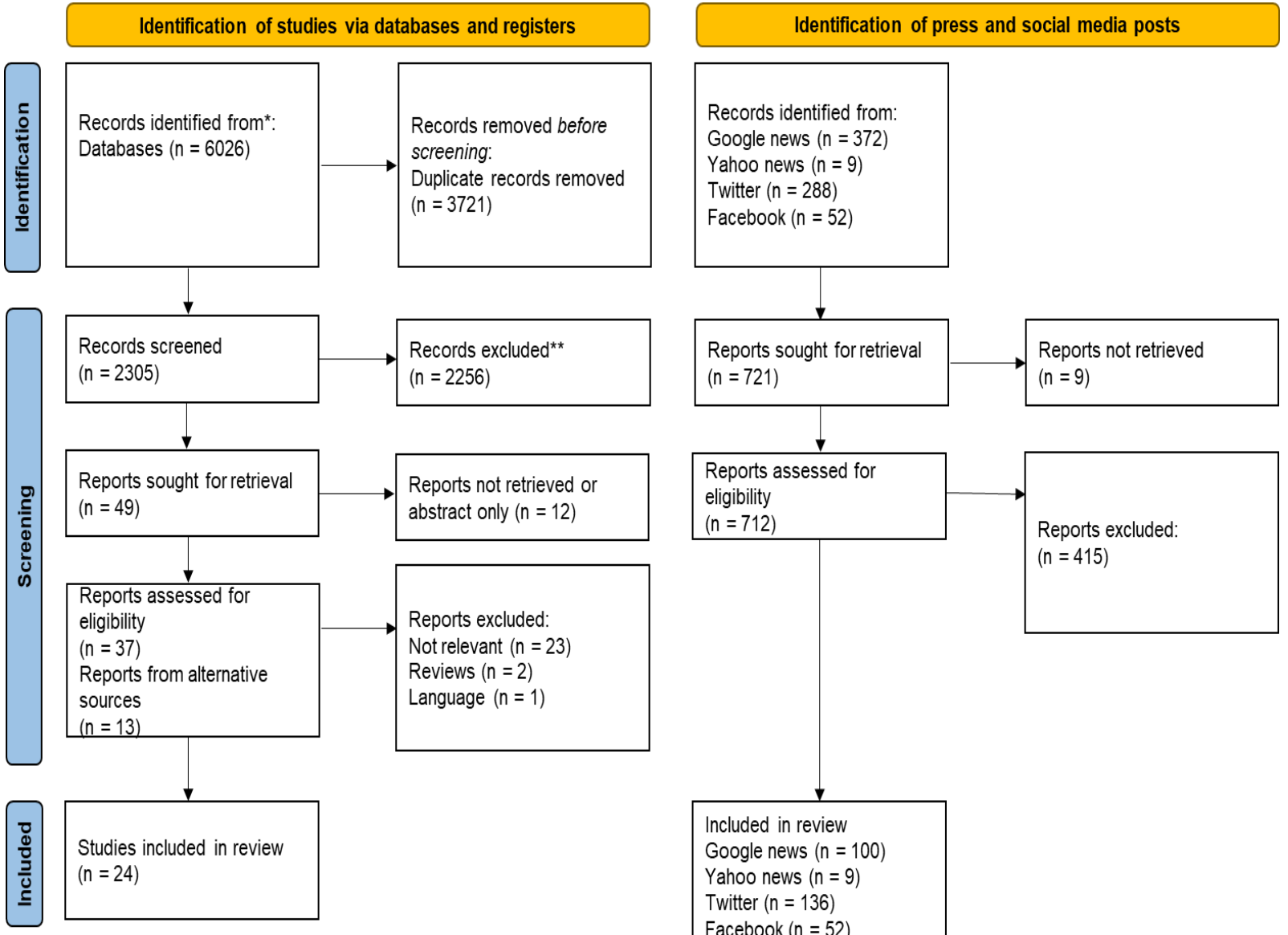
News and social media

Review sources

- **Scientific articles:**
  - Web of Science Core Collection
  - Biological Abstracts
  - BIOSIS Citation Index
  - MEDLINE Complete
  - Agricola
  - CAB Abstracts
  - FSTA – Food Science and Technology Abstracts
  - Biological & Agricultural Index Plus
  - Scopus
  - ProQuest

- News
  - Google News
  - Yahoo News
  - Manual search
- Social media
  - Twitter
  - Facebook

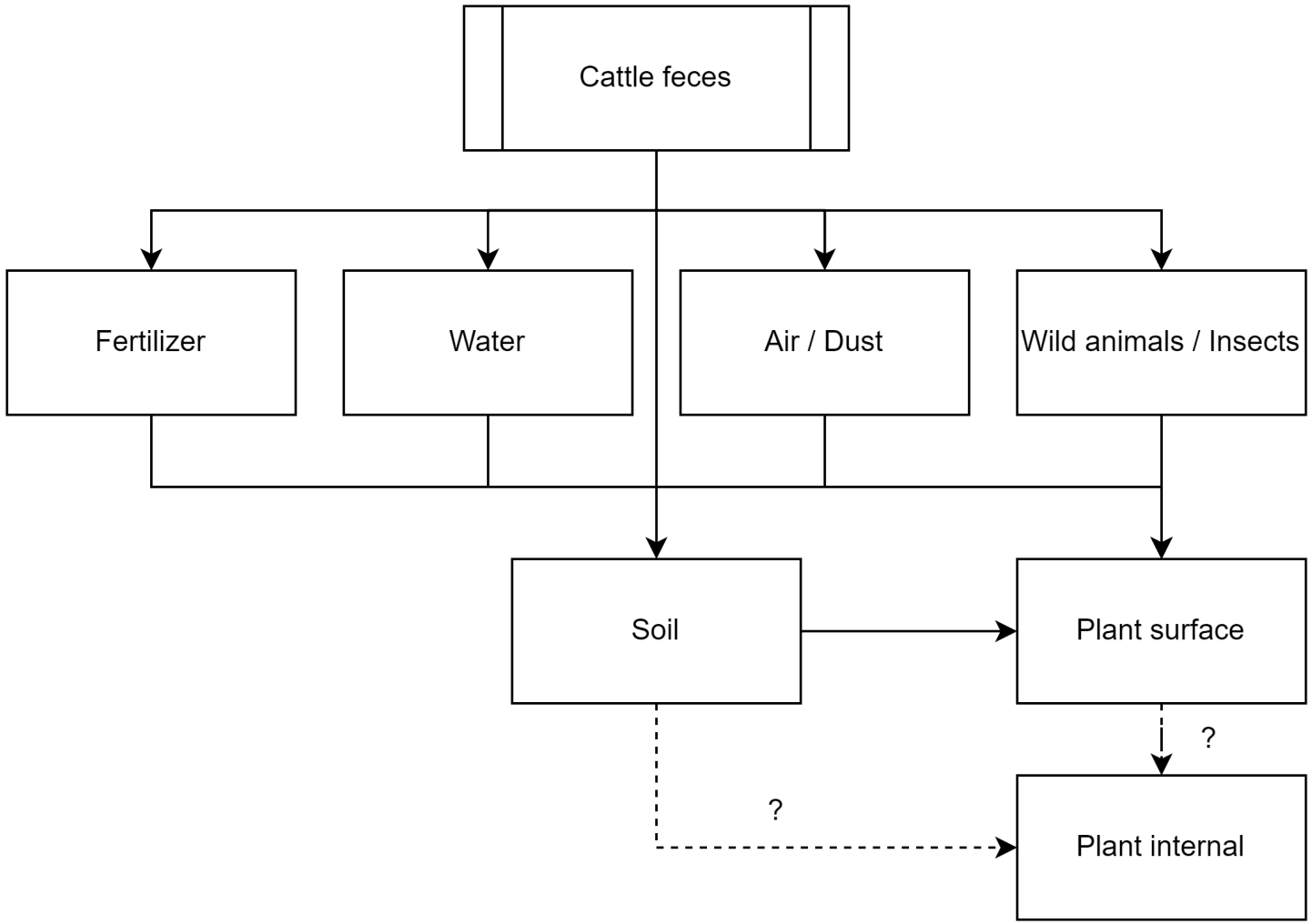
Literature search flowchart



Scientific Articles

Location		Etiology		Produce		Animal Source		Mechanism of Transmission	
California	11	*E. coli* O157:H7	16	Lettuce	8	Beef cattle	11	Airborne	7
Tennessee	3	Generic *E. coli*	6	Spinach	8	Dairy cattle	5	Insects	6
North Carolina	3	*Salmonella*	5	Leafy greens	3	Unspecified cattle	4	Water	5
NR	2	STEC	3	Turnip Greens	3	Poultry	3	Wild animals	4
Nebraska	2	*E. coli* O145	1	Fresh produce	2	Unspecified livestock	1	Soil	4
Oregon	1	*Campylobacter*	1	Mustard greens	2	Sheep	1	Not identified	2
Nigeria	1	non-O157 STEC	1	Tomatoes	2	Not specified	1	Runoff	2
Maryland	1	AMR *E. coli*	1	Squash	2	Swine	1	Manure	1
Korea	1	*L. Monocytogenes*	1	Beans	1	Small ruminants	1	Not specified	1
Arizona	1	*Listeria* spp.	1	Iceberg lettuce	1	Chicken	1	Cattle (intrusion)	1
		Coliforms	1	Romaine lettuce	1				
				Strawberries	1				
		Total *E. coli*	28	Alfalfa	1				
				Not specified	1				
				Broccoli	1				
				Cucumber	1				
				Spinach	1				

Proposed pathways of contamination of leafy greens – From Literature



Water

- Pathogens often isolated from water resources and reservoirs used for pre- and post-harvest operations.
- Runoff from cattle feedlots and grazing areas is considered as an important mechanism of transmission.
- Water supply failures cause contamination of clean water (i.e. backflow).
- Suggested mitigation strategies:
  - Risk-based management approach.
  - Water safety plan for farms.
  - Inspection of water supply systems.
  - Vegetative buffer zones to contain runoff.

Airborne Transmission

- Airborne dissemination from feedlots to leafy greens is possible via dust or aerosol.
- Pathogens can reach to produce fields at least 180 m away.
- Amount of dust and meteorological factors (i.e. rainfall, wind speed) are important factors.
- Suggested mitigation activities:
  - Increased distance
  - Vegetative barriers
  - Dust control
  - Cattle management

Wild Animals and Insects

- Wild animals (usually feral swine) can transfer pathogens from grazing areas to leafy greens if access is not restricted.
- Wild animals can get pathogens from cattle and transfer to other swine, cattle and water sources.
- Insects, especially flies, can harbor and carry cattle related pathogens in long distances.
  - One study found that distance was not an important factor for transmission of antimicrobial resistant *E. coli.*
- Ability of flies to carry and contaminate spinach leaves through contact, defecation and regurgitation was demonstrated.
- Role and impact of flies in transmission is not yet definitive and more studies recommended.

Wild Animals and Insects

- Suggested mitigation strategies:
  - Limiting wild animal and insect intrusion into fields.
  - Agricultural chemicals (insecticides), however, it is also noted that chemicals can affect microbiological competition in favor of pathogens.

Suggested Management Strategies

- Reassess distance limits between livestock and produce farms and increase if necessary.
- Implement buffer zones.
- Improved sampling of fresh produce.
- Prevent animal intrusion into growing fields and surface water.
- Reduce pre-harvest cattle contamination.
- Risk-based water quality management.

CONCLUSIONS
from Scientific Article Search

None of the proposed mechanisms were definitively related to contamination of leafy greens quantitatively.

Relative contribution of the transmission pathways are still unknown.

Interactions between livestock, fresh produce and environment are complex, more studies are needed.

Mitigation strategies should focus on wholistic approaches, rather than concentrating on individual pathways.

Most research focus on *E. coli* (especially STEC) but the impact of *Salmonella, Listeria* and other pathogens may be overlooked.

Official reports (Government) relating cattle to produce outbreaks

Document type	Outbreak date	Hazard	Produce	Involvement of livestock
Outbreak investigation	September 2006	*E. coli* O157:H7	Spinach	Potential source
Environmental assessment	Spring 2010	*E. coli* O145	Romaine	Suspected, not likely
Environmental assessment	August 2012	Salmonella	Whole Cantaloupe	Suspected, no link found
Outbreak investigation	November 2013	*E. coli* O157:H7	Lettuce (RTE Salad)	Possible source
Outbreak investigation	Fall 2018	*E. coli* O157:H7	Romaine	Hypothesized
Outbreak investigation	November 2019	*E. coli* O157:H7	Romaine	Potential source
Outbreak investigation	December 2019	*E. coli* O157:H7	Salad mix	Potential source
Outbreak investigation	Fall 2019	*E. coli* O157:H7	Romaine	Potential source
Outbreak investigation	June-October 2020	*Salmonella* Newport	Red Onions	Suspected, not identified
Outbreak investigation	Summer 2020	*Salmonella* Enteritidis	Peaches	Potential source
Outbreak investigation	Fall 2020	*E. coli* O157:H7	Leafy greens (various)	Potential source
Outbreak investigation	Fall 2020	*E. coli* O157:H7	Leafy greens (various)	Potential source
Statement	Fall 2020	*E. coli* O157:H7	Leafy greens	-
Action plan	Not an outbreak	STEC	Leafy greens (various)	-

September 2006 – CDC Report

- Food vehicle: Spinach
- Etiology: *E. coli* O157:H7
- Location: California
- PFGE patterns from outbreak cases and spinach matched with cattle and wild pig feces, water and sediment samples.
- Cattle and pigs had access to a nearby river.

- Potential factors:
  - Runoff from grazing
  - Irrigation wells
  - Depth of groundwater and surface water
  - Use of surface water
- Recommendations:
  - Limit cattle and wild animal intrusion to surface water resources.
  - Monitor and improve water quality.

November 2013 - FDA

- Food vehicle: RTE Salad (romaine lettuce)
- Etiology: *E. coli* O157:H7
- Location: California
- Soil and water samples tested positive but no match with the outbreak strain.
- Proximity of cattle was suggested as a risk factor.

- Potential factors:
  - Two nearby cattle operations
- Recommendations:
  - Raw fresh produce growers, packers and shippers are recommended to follow “The Guide to Minimize Microbial Safety Hazards”, GAPs and GMPs.

Fall 2019 - FDA

- Food vehicle: Romaine lettuce, chopped salad kits
- Etiology: *E. coli* O157:H7
- Location: California
- One outbreak strain detected from a fecal sample 2 miles upslope.
- STEC strains not related to outbreaks were found near crops, a farm next to cattle grazing and water drainage.

- Potential factors:
  - Proximity of cattle
- Recommendations:
  - FDA released “Leafy Greens STEC Action Plan” as a response

Findings from this investigation and other leafy green outbreaks since 2013 suggest the “proximity of cattle” as a potential contributing factor.

Summer 2020 - FDA

- Food vehicle: Peaches
- Etiology: *Salmonella* Enteritidis
- Location: California
- A number of isolates were found that resemble historical chicken and cattle isolates, but not the outbreak strain.
- “Plausible” airborne transmission via fugitive dust “possibly” originating from adjacent animal operations.

- Potential factors:
  - Adjacent animal operations
  - Dust caused by dry air and agricultural operations
- Recommendations:
  - Be aware and assess the risks of adjacent land use (especially livestock)
  - Implement science- and risk-based preventive measures.
  - Improve sampling.
  - Implement root cause analysis.
  - Improve traceability

Fall 2020 - FDA

- Food vehicle: Leafy greens
- Etiology: *E. coli* O157:H7
- Location: California
- Outbreak strain matched to Fall 2019 romaine lettuce outbreak strain.
- Cattle are “most likely” source.
  - Consistent recovery of outbreak strains.
  - Positive fecal sample 1.3 miles upslope from produce farm.
- It is **not clear** how the pathogen is moving in the environment and contaminating leafy greens.

- Potential factors:
  - Cattle grazing on adjacent land.
  - Animal intrusion.
- Recommendations:
  - Consider *E. coli* O157:H7 in produce as a **reasonably foreseeable hazard.**
  - California Longitudinal Study.
  - Be aware of risks related to adjacent land, especially livestock presence.
  - Encourage collaboration with adjacent and nearby livestock owners.
  - Improve sampling.
  - Implement root cause analysis.
  - Improve traceability

Leafy Greens STEC Action Plan (LGAP) – 2020

- In response to reoccurring outbreaks related to same produce and geography.
- Contaminated soil, fertilizers, animals, air/dust and water are recognized as possible contamination sources.

Priority areas:

- Prevention
- Response
- Addressing knowledge gaps

LGAP – Actions related to adjacent/nearby land and livestock operations

- Prevention:
  - Increase awareness and address concerns round adjacent and nearby land use: Enhance coordination of stakeholders for strategies to minimize risks by nearby and adjacent livestock.
- Response:
  - Follow-up surveillance: Special emphasis on soil amendment and adjacent land to understand cattle distribution and movements.
- Addressing knowledge gaps:
  - Adjacent and nearby land use: Collaboration with federal and state partners, research organizations and industry to identify knowledge gaps on adjacent/nearby land use.
  - Adjacent and nearby land use: Communication and engagement to understand current practices and options for pre-harvest management strategies.
  - Adjacent and nearby land use: Conduct literature review and research on vaccination or feed additives for cattle.

OVERALL CONCLUSIONS

- Scientific Literature and Government Reports Suggested Cattle as a POTENTIAL source of contamination
- No Mechanism of contamination was identified (From Cattle to Field)
- Media reports indicate that consumers gravitate towards blaming livestock expressing emotional responses
- Other Potential Sources were also Identified but were not emphasized in media reports or in consumer reactions

Research Needs

- Determine the Actual Risk of Cattle Proximity to Produce Contamination through Data in order to make Science-Based Decisions
- Determine Mechanisms of Trasfer of Pathogens from Cattle to Produce and Produce to Cattle
- Determine Role of Environment (Dust, Water, Soil)
- Explore Pre-Harvest Mitigation Strategies for Livestock and Produce

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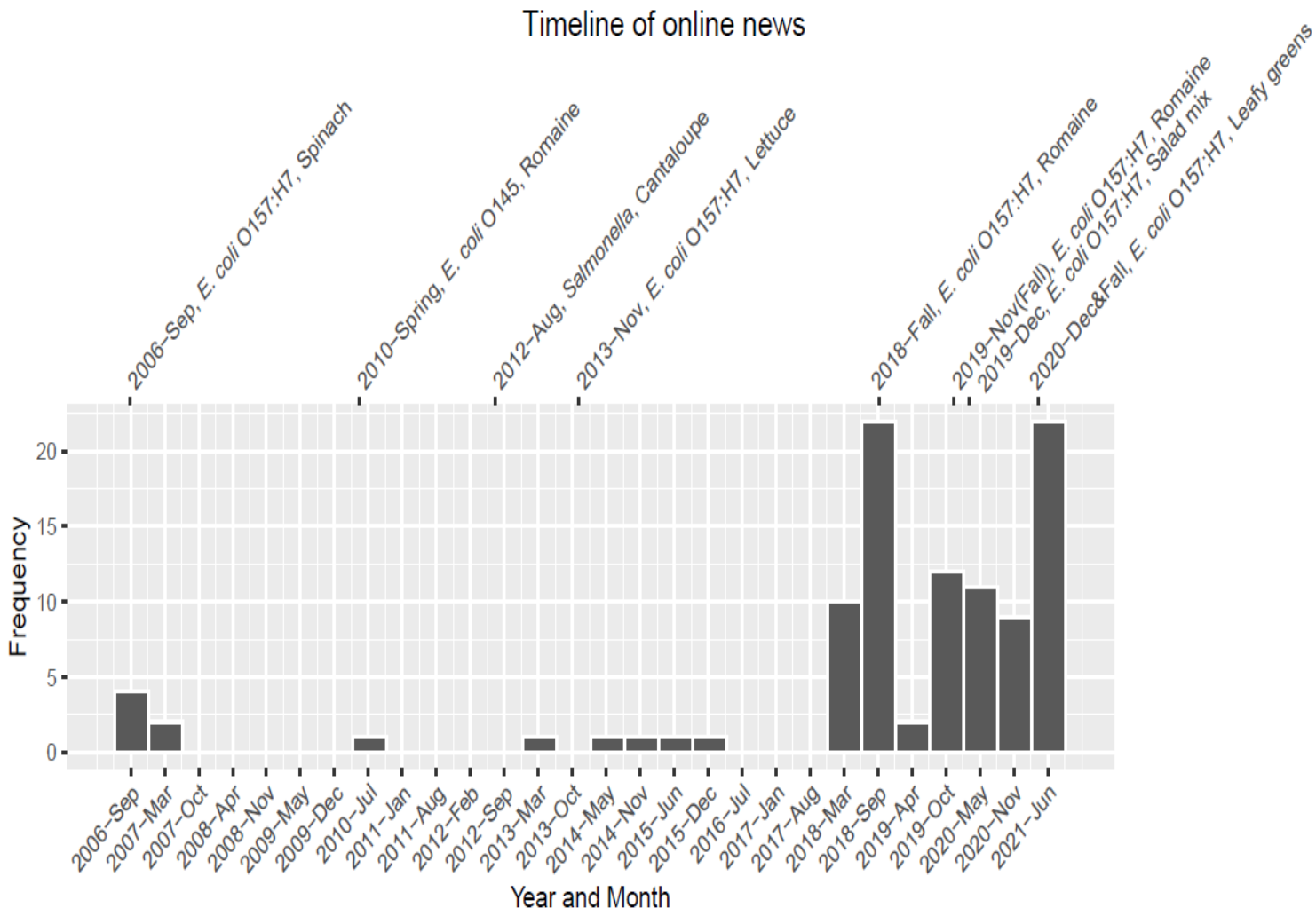
Questions and Discussion

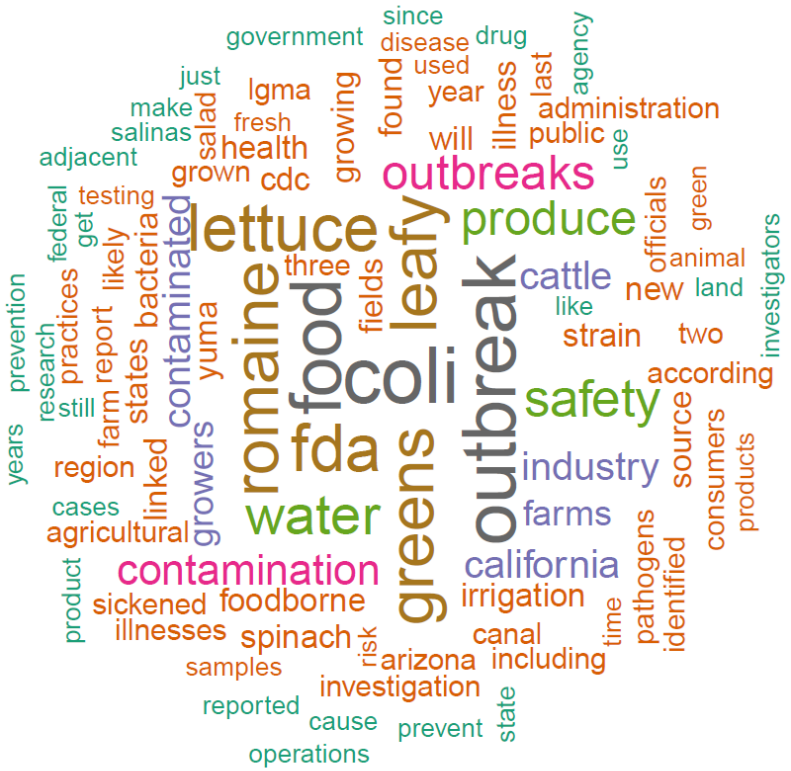
News

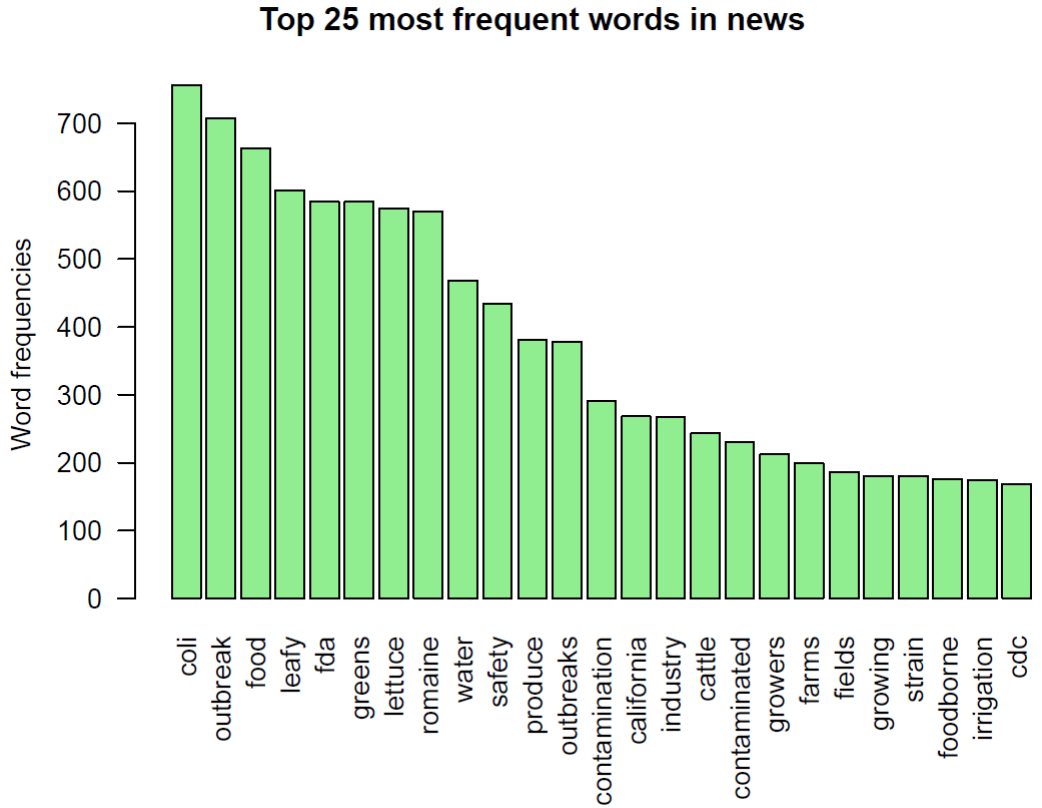

Timeline of online news
2006–Sep, E. coli O157:H7, Spinach
2010–Spring, E. coli O145, Romaine
2012–Aug, Salmonella, Cantaloupe
2013–Nov, E. coli O157:H7, Lettuce
2018–Fall, E. coli O157:H7, Romaine
2019–Nov(Fall), E. coli O157:H7, Romaine
2019–Dec, E. coli O157:H7, Salad mix
2020–Dec&Fall, E. coli O157:H7, Leafy greens
Frequency
0
5
10
15
20
2006–Sep
2007–Mar
2007–Oct
2008–Apr
2008–Nov
2009–May
2009–Dec
2010–Jul
2011–Jan
2011–Aug
2012–Feb
2012–Sep
2013–Mar
2013–Oct
2014–May
2014–Nov
2015–Jun
2015–Dec
2016–Jul
2017–Jan
2017–Aug
2018–Mar
2018–Sep
2019–Apr
2019–Oct
2020–May
2020–Nov
2021–Jun
Year and Month

News

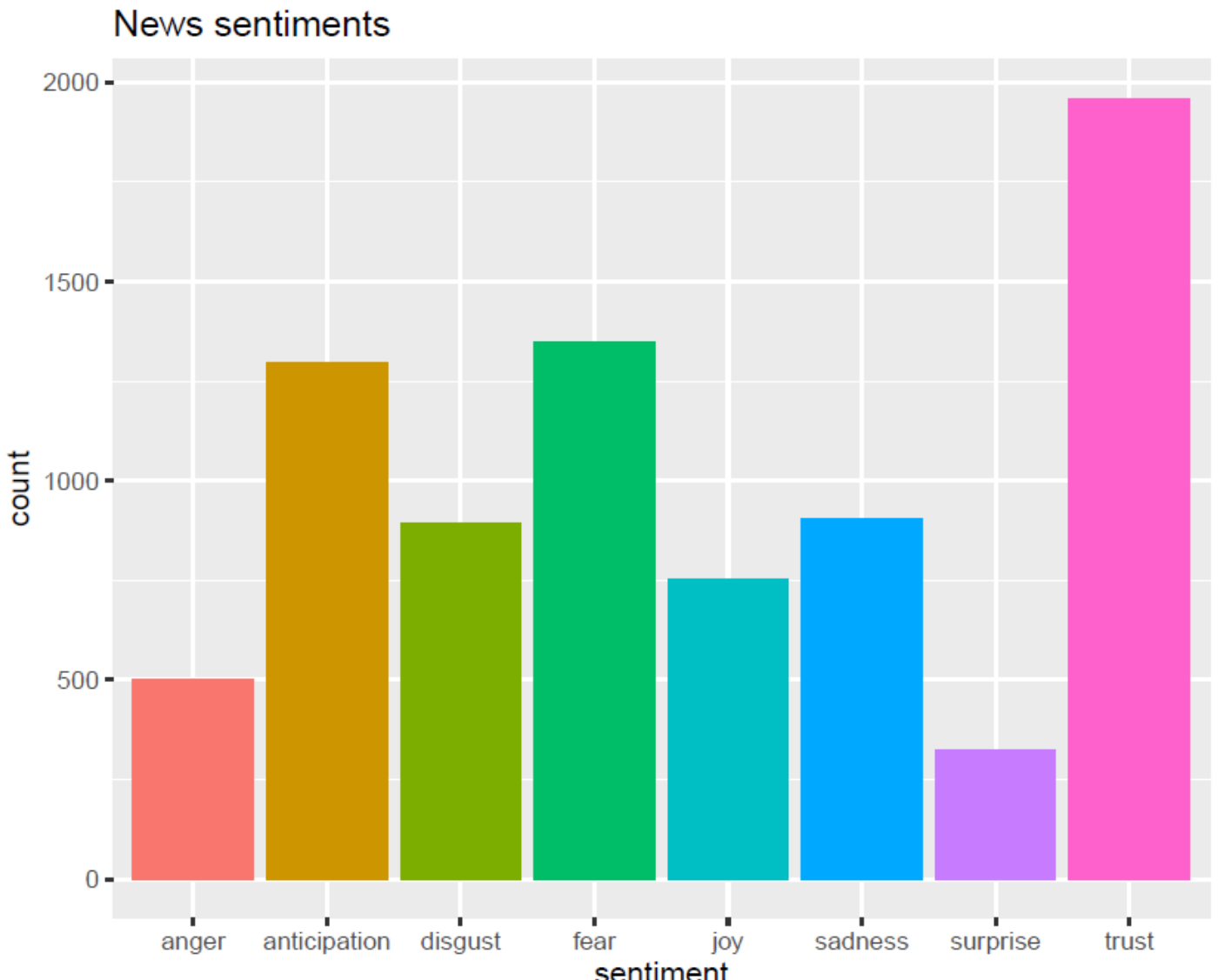
- Mostly from food and agriculture related news sites.
- Not much coverage on large media outlets:
  - Less attention to food safety?
  - Search methods?
- Most only report public announcements and recall notices from FDA without further comment.

Word analysis of news content

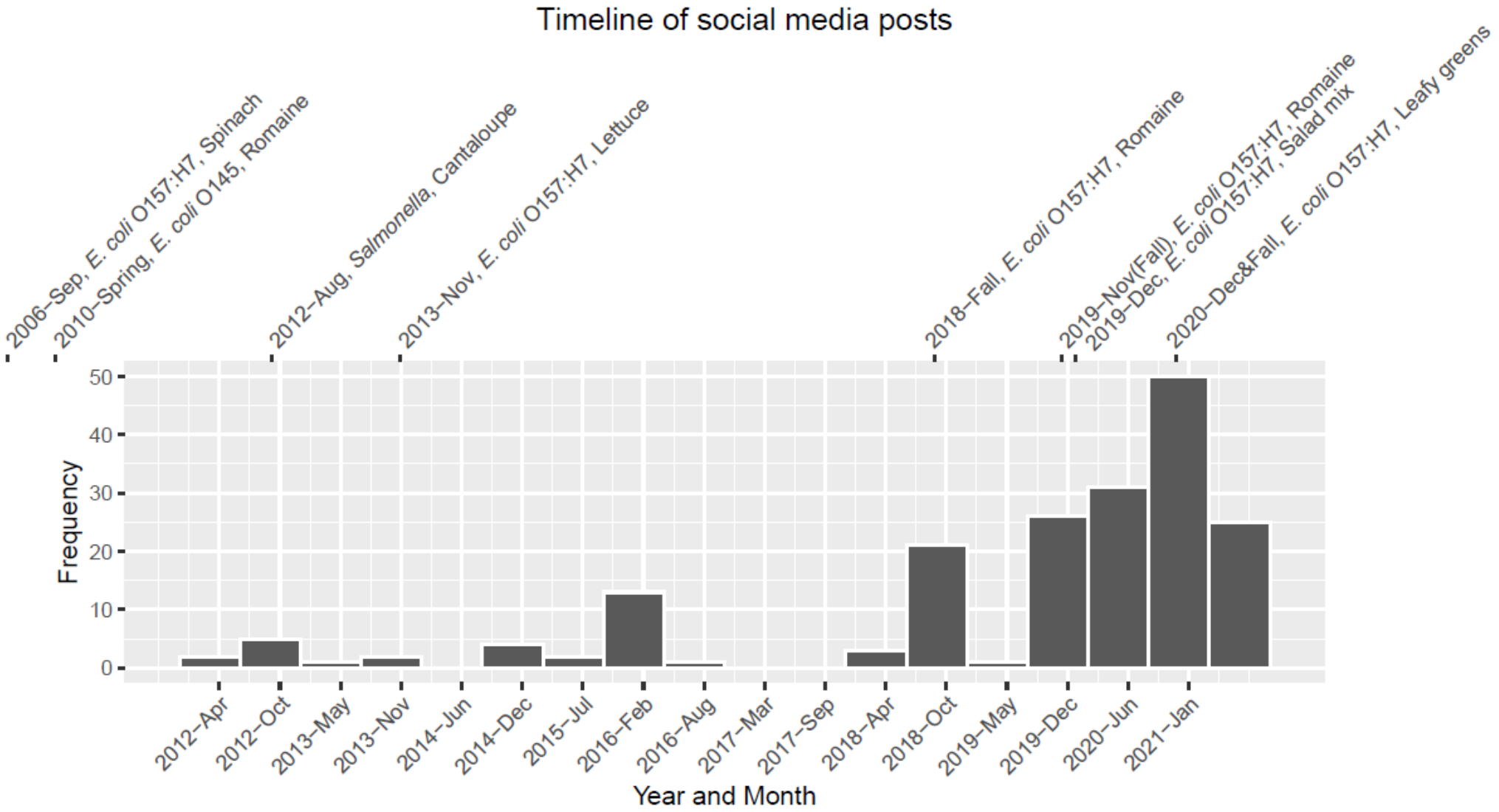




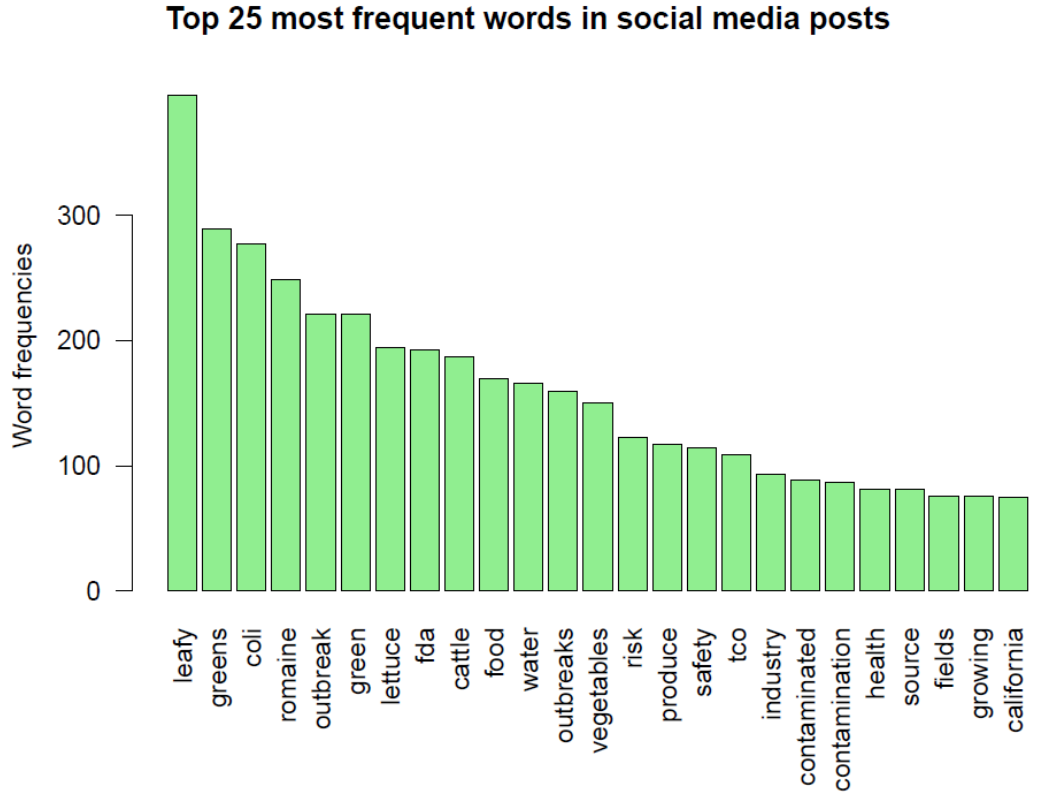
Emotions in news



Social media



Word analysis of social media posts



Emotions in social media posts