THE UNIVERSITY OF ARIZONA
Mel & Enid Zuckerman College of Public Health

Natural hazards and public health infrastructure in the United States

Jeonggyo Yoon[1], Chris C. Lim[1]

[1] Department of Community, Environment, and Policy, Zuckerman College of Public Health, The University of Arizona, Tucson, Arizona, US
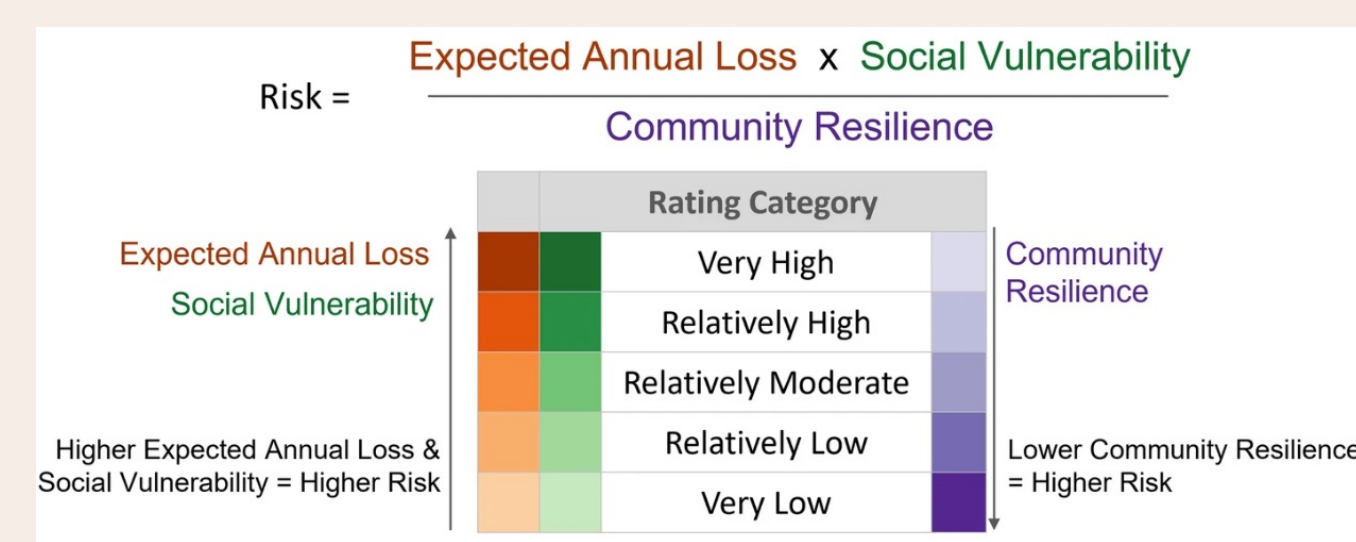
THE UNIVERSITY OF ARIZONA

INTRODUCTION

❖ From 1980 to 2022, the U.S. has seen 341 weather and climate disasters with damages and costs exceeding $1 billion. These 341 events have cost more than $2.480 trillion overall (Smith, 2021).

❖ Given that climate change poses a significant threat to public health infrastructure by threatening the quality and continuity of medical care services and damaging facility capacity, identifying and quantifying the number of infrastructure at risk is needed.

❖ This study aims to quantify the percentage of public health infrastructures at risk to climate change-related natural hazards in the U.S.

METHODS

❖ _Natural Hazard Risk_ (Zuzak et al., 2022)
- Dataset: Federal Emergency Management Agency (FEMA)
- Hazard type: Avalanche, coastal flooding, cold wave, drought, earthquake, hail, hurricane, heat wave, ice storm, landslide, lightning, riverine flooding, strong wind, tornado, tsunami, volcanic activity, wildfire, and winter weather.
- Risk calculation by each natural hazard

Risk score (0~100)

$$Risk = \frac{Expected\ Annual\ Loss \times Social\ Vulnerability}{Community\ Resilience}$$

Expected Annual Loss / Social Vulnerability ... Community Resilience

Rating Category:
Very High / Relatively High / Relatively Moderate / Relatively Low / Very Low

Higher Expected Annual Loss & Social Vulnerability = Higher Risk ... Lower Community Resilience = Higher Risk

Risk index rating (Qualitative rating)

County	Expected Annual Loss	Social Vulnerability	Community Resilience	Risk
County 1	100	45	52	100
County 2	26	94	58	55
County 3	54	48	35	51
County 4	16	92	56	37
County 5	32	36	44	24
County 6	22	45	43	22
County 7	9	69	59	15
County 8	25	21	57	13
County 9	10	44	45	9
County 10	16	4	39	1

Risk Index:
Very High / Relatively High / Relatively Moderate / Relatively Low / Very Low / No Rating / Not Applicable / Insufficient Data

→ k-means clustering or natural breaks from risk score
→ Very or Relatively high

- **Composite hazard** (All-hazard risk index) measures the relative risk of a community based on all 18 natural hazards included in the Index by comparing its composite Risk Index value with other communities at the same level.

❖ _Public Health Infrastructures_ (Locations)
- Dataset: Homeland Infrastructure Foundation-Level Data (HIFLD)
- Infrastructure type: Hospitals, Nursing Homes, and Urgent Care Facilities

❖ _Analysis_
- Visualization of the hazard risk index ratings and infrastructure locations in the U.S.
- Calculated the percentage of infrastructures, particularly, those located in high natural hazard risks area.

DISCUSSION

❖ We visualized 18 types of natural hazards with 3 types of public health infrastructures. Single- and multiple-hazard risks showed variable geographical patterns, whereas most public health infrastructures were condensed in the central-eastern area.

❖ Future studies plan to quantify and predict multiple combinations of hazard risks precisely around public health facilities.
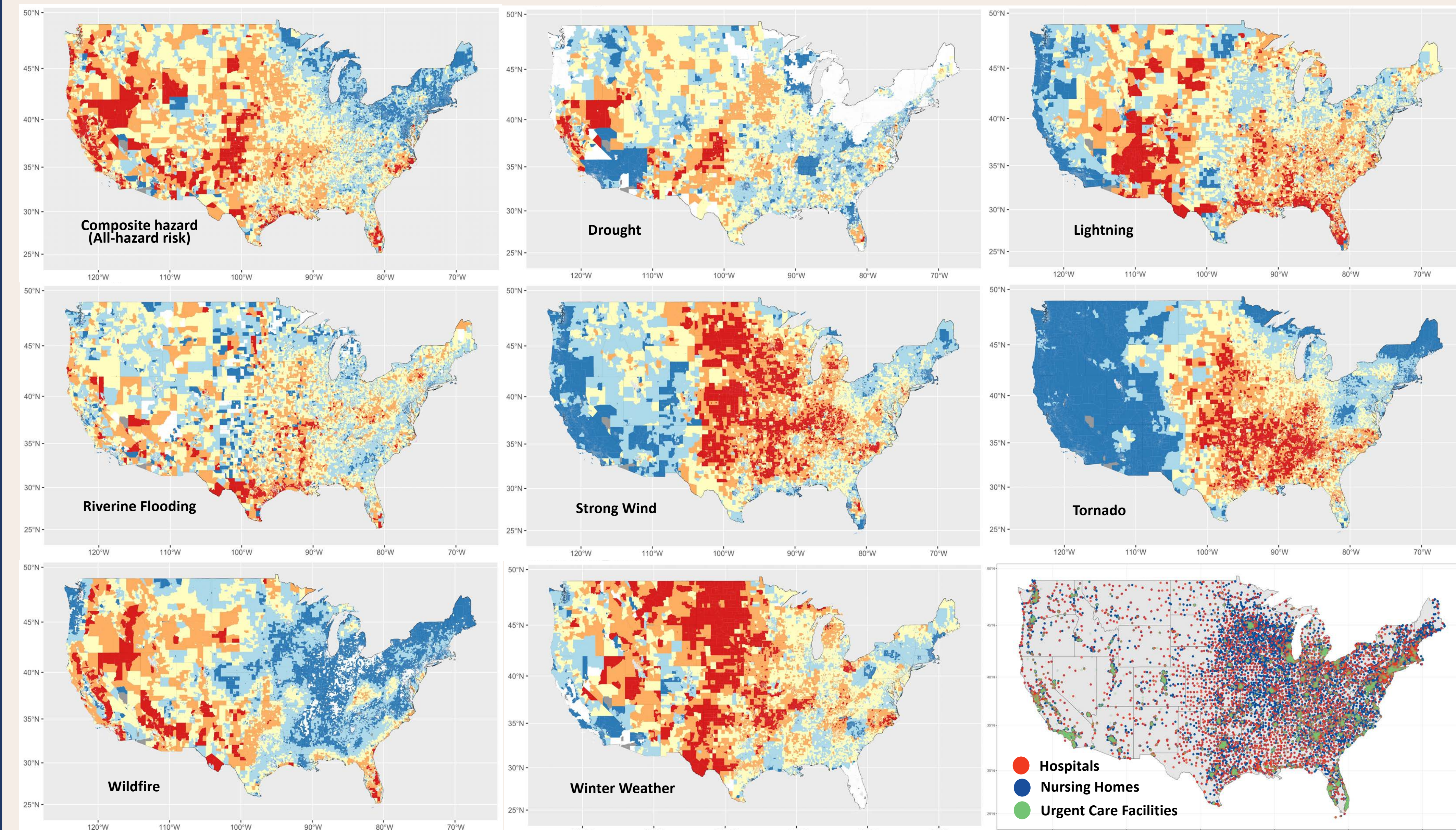
RESULTS

Figure 1. Risk index ratings for natural hazard (composite hazard, drought, lightning, riverine flooding, strong wind, tornado, wildfire, and winter weather) at census tracts and the locations of public health infrastructures (hospitals, nursing homes, urgent care facilities) in the U.S.

The majority of public health infrastructures were concentrated in the central-eastern area, where the higher risk of a tornado and strong wind was reported, while the higher risk of drought, riverine flooding, and wildfire was reported in the south-western area.

Table 1. The number and percentage of infrastructures[1] located at higher risk of natural hazards.

	Hospitals (N=7,954)			Nursing homes (N=45,148)			Urgent care facilities (N=4,764)		
	Very High	Relatively High	Very or Relatively High	Very High	Relatively High	Very or Relatively High	Very High	Relatively High	Very or Relatively High
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Hazards[1]									
Composite hazard	293 (3.68)	1,478 (18.58)	1,771 (22.27)	1,006 (2.23)	5,982 (13.25)	6,988 (15.48)	127 (2.67)	716 (15.03)	843 (17.70)
Drought	25 (0.31)	181 (2.28)	206 (2.59)	60 (0.13)	760 (1.68)	820 (1.82)	4 (0.08)	21 (0.44)	25 (0.53)
Lightning	637 (8.01)	1,810 (22.76)	2,447 (30.77)	3,264 (7.23)	9,892 (21.91)	13,156 (29.14)	278 (5.84)	936 (19.65)	1,214 (25.48)
Riverine flooding	283 (3.56)	1,014 (12.75)	1,297 (16.31)	1,054 (2.34)	4,818 (10.67)	5,872 (13.01)	127 (2.67)	476 (9.99)	603 (12.66)
Strong wind	990 (12.45)	1,649 (20.73)	2,639 (33.18)	4,462 (9.88)	8,736 (19.35)	13,198 (29.23)	300 (6.30)	745 (15.64)	1,045 (21.94)
Tornado	1,166 (14.66)	1,829 (23.00)	2,995 (37.65)	4,419 (9.79)	8,875 (19.66)	13,294 (29.45)	437 (9.17)	973 (20.42)	1,410 (29.60)
Wildfire	55 (0.69)	284 (3.57)	339 (4.26)	215 (0.48)	1,261 (2.79)	1476 (3.27)	24 (0.50)	137 (2.88)	161 (3.38)
Winter weather	766 (9.63)	1,666 (20.95)	2,432 (30.58)	2,737 (6.06)	8,300 (18.38)	11,037 (24.45)	205 (4.30)	772 (16.21)	977 (20.51)

[1] Hospitals including children, chronic disease, critical access, general acute care, long-term care, military, psychiatric, rehabilitation, special, and women hospitals based on data acquired from various state departments or federal sources; Nursing homes also include assisted care facilities that house elderly adults. The purpose of this data is to provide accurate locations for high concentrations of elderly adults in the event of a disaster; Urgent care facilities consist of any location that is capable of providing emergency medical care and must provide emergency medical treatment beyond what can normally be provided by an EMS unit, must be able to perform surgery, or must be able to provide recuperative care beyond what is normally provided by a doctor's office. In times of emergency, the facility must be able to accept patients from the general population or patients from a significant subset of the general population (e.g., children).

[2] Drought is a deficiency of precipitation over an extended period of time resulting in a water shortage; Lightning is a visible electrical discharge or spark of electricity in the atmosphere between clouds, the air, and/or the ground often produced by a thunderstorm; Riverine Flooding is when streams and rivers exceed the capacity of their natural or constructed channels to accommodate water flow and water overflows the banks, spilling into adjacent low-lying, dry land; Strong Wind consists of damaging winds, often originating from thunderstorms, that are classified as exceeding 58 mph; Tornado is a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground and is visible only if it forms a condensation funnel made up of water droplets, dust, and debris; Wildfire is an unplanned fire burning in natural or wildland areas, such as forest, shrub lands, grasslands, or prairies. Winter Weather consists of winter storm events in which the main types of precipitation are snow, sleet, or freezing rain.

CONCLUSION

❖ The spatial mapping of public health infrastructure and natural hazards can inform policymakers and public health officials in prioritizing resources for the most vulnerable areas.