IOWA STATE UNIVERSITY
Department of Industrial and Manufacturing Systems Engineering

Evaluating the Hurricane Decision Simulator

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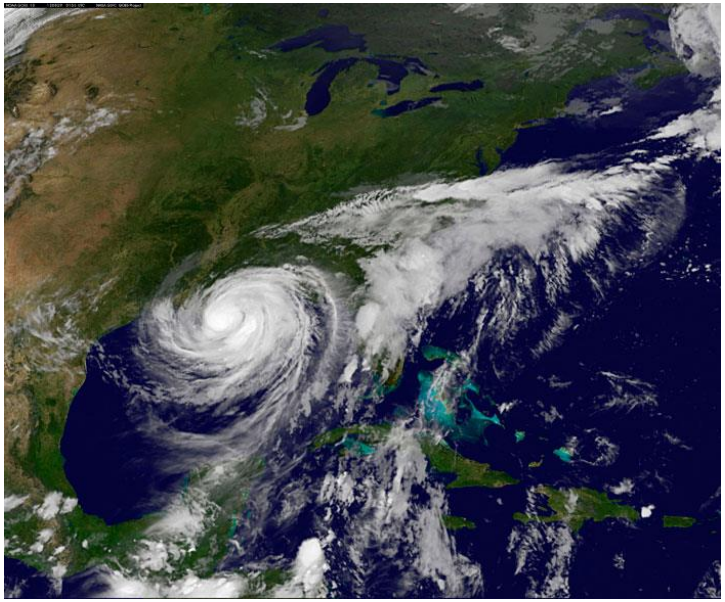


MFR Decision Support Matrix

Hours before arrival of 39-mph winds

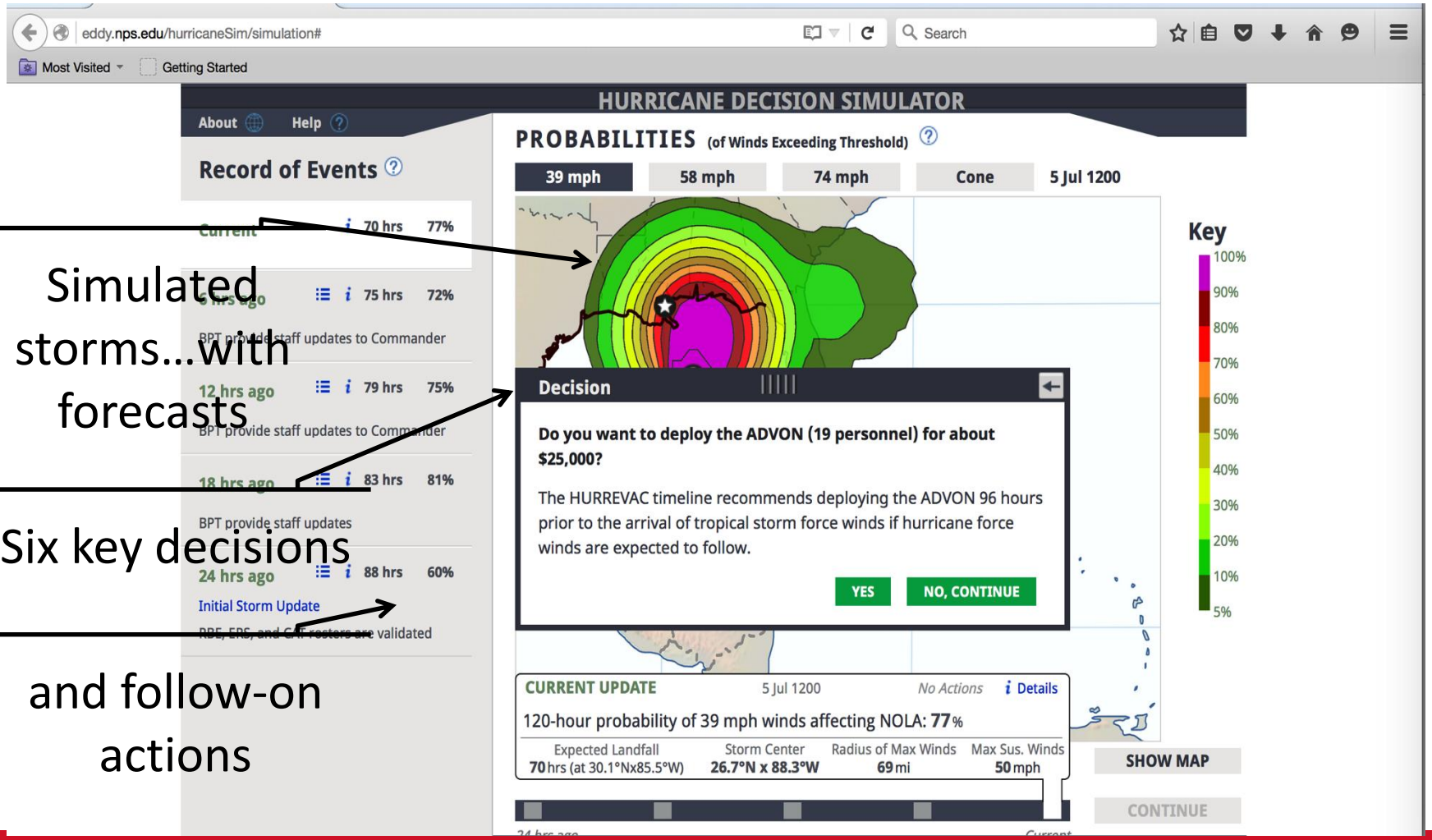
1. 96 hours: Send advance emergency relocation staff (ERS) to alternate headquarters
2. 96 hours: Send liaison officers to local municipal emergency operations centers
3. 72 hours: Send rest of ERS to alternate headquarters
4. 72 hours: Activate remain behind element to stay if evacuation ordered
5. 60 hours: Evacuate or shelter in place
6. 48 hours: Transfer command and control to alternate headquarters

Hurricane Decision Simulator

- Training tool to make hurricane preparation decisions
- Key characteristics
  - Simulated storms (storm and forecasts)
  - User decisions
  - Actions of other entities
  - Consequences of storm plus decisions

Regnier, E., & MacKenzie, C.A. (2017). The Hurricane Decision Simulator: A tool for Marine Forces in New Orleans to practice operations management in advance of a hurricane. *Manufacturing & Service Operations Management*. In press.

Hurricane Decision Simulator



Simulated storms…with forecasts

Six key decisions

and follow-on actions

About Help Share

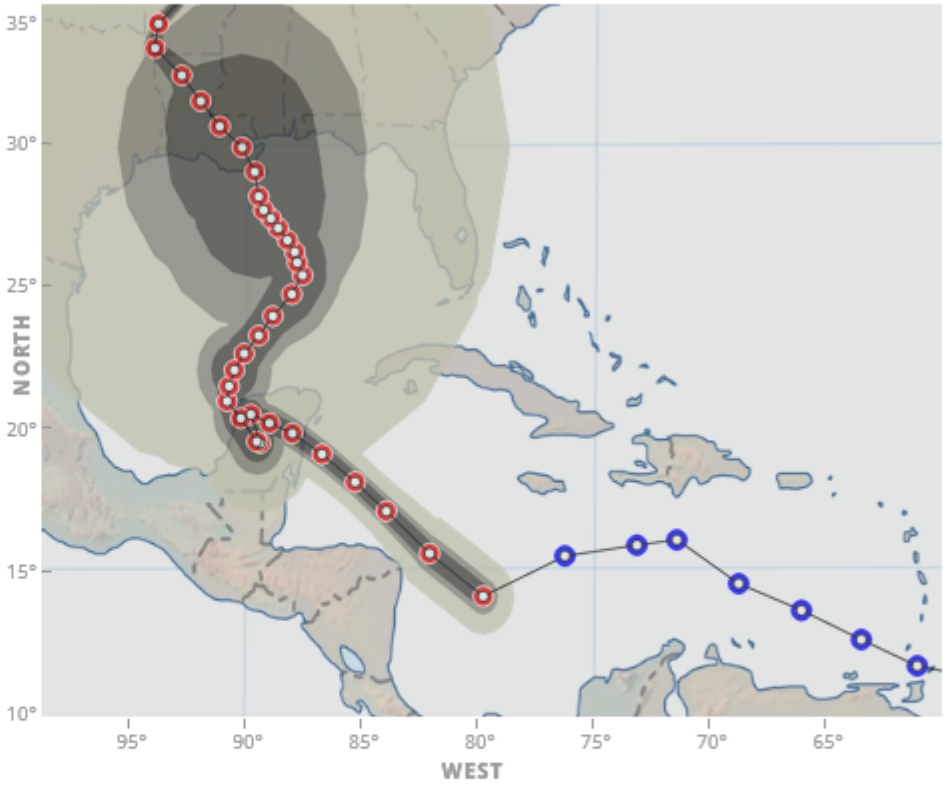
Simulation Over

Results:

The storm made landfall at 30.0°N and 90.3°W as a Category 2 hurricane. The storm made landfall on 11 Aug 0800, 246 hours after the NHC's first forecast of this storm. NOLA experienced 104 mph winds, 12 hours before the storm made landfall. Landfall occurs when the center of the storm reaches the coastline, but high winds often reach land much earlier, especially for large or intense storms. Tropical storm force winds (39 mph or greater) reached NOLA about 24 hours before the storm made landfall.

The storm surge was 4.0 feet and occurred at low tide.

You deployed the ADVON 54 hours before NOLA experienced 39 mph winds.
You deployed liaison officers to local municipal EOCs 48 hours before NOLA experienced 39 mph winds.
You deployed the rest of the ERS to the alternate HQ 42 hours before NOLA experienced 39 mph winds.



REVIEW NEW SIMULATION

Hurricane condition readiness 2 and HQ...
204 hrs ago
Current

Use by the Marines

- Individual training by crisis action team and emergency relocation team (almost 200 people) since Fall 2015
- Used in developing annual (team) specialized hurricane exercises
- Expanded to Hialeah Reserve Training in Florida in June for command turnover

Research question

- Does the Hurricane Decision Simulator help people make better decisions?

- How does the Hurricane Decision Simulator impact or change people's decision making?

Subjects

- Engineering economy class in Spring 2017
- 157 undergraduate students, engineering majors
- Mostly juniors and seniors

Text description (day 1)

- You are the Commander of U.S. Marine Forces Reserves (MARFORRES) whose headquarters are located in New Orleans, Louisiana. …
- Tropical cyclone
  - Probability of tropical force winds
  - Probability of hurricane winds
  - Expected time to landfall
- Evacuation costs
- Marines timeline

Evacuate, shelter in place, neither?

Three scenarios

	Probability wind speed > 39 mph	Probability wind speed > 74 mph	Expected hours to landfall
Scenario 1	77	31	58
Scenario 2	84	22	59
Scenario 3	100	52	58

- Costs of evacuation = $300,000 per day for 1-2 weeks
- Marines' timeline recommends evacuating 60 hours before arrival of winds

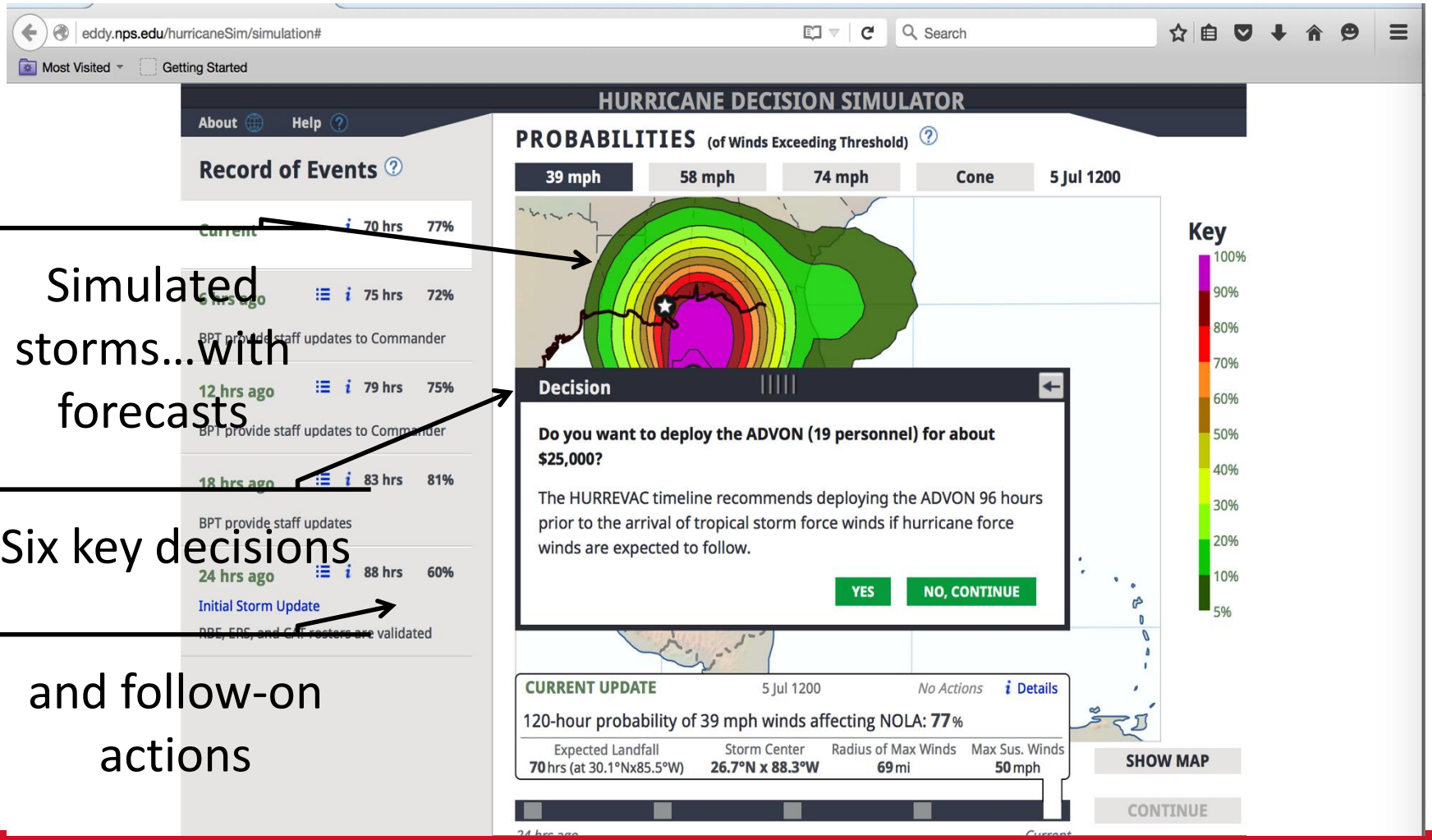
Experiment

- Introduction to the Hurricane Decision Simulator (HDS)
- Subjects practiced with HDS (~15 minutes)

Day 2

- Each subject made decisions for the exact same 5 storms in HDS
- Subjects recorded information
  - Details of the storm
  - Riskiness of storm
  - Subjective evaluation of decision-making processes
- Final 3 storms in HDS equivalent to text description on day 1

Hurricane Decision Simulator

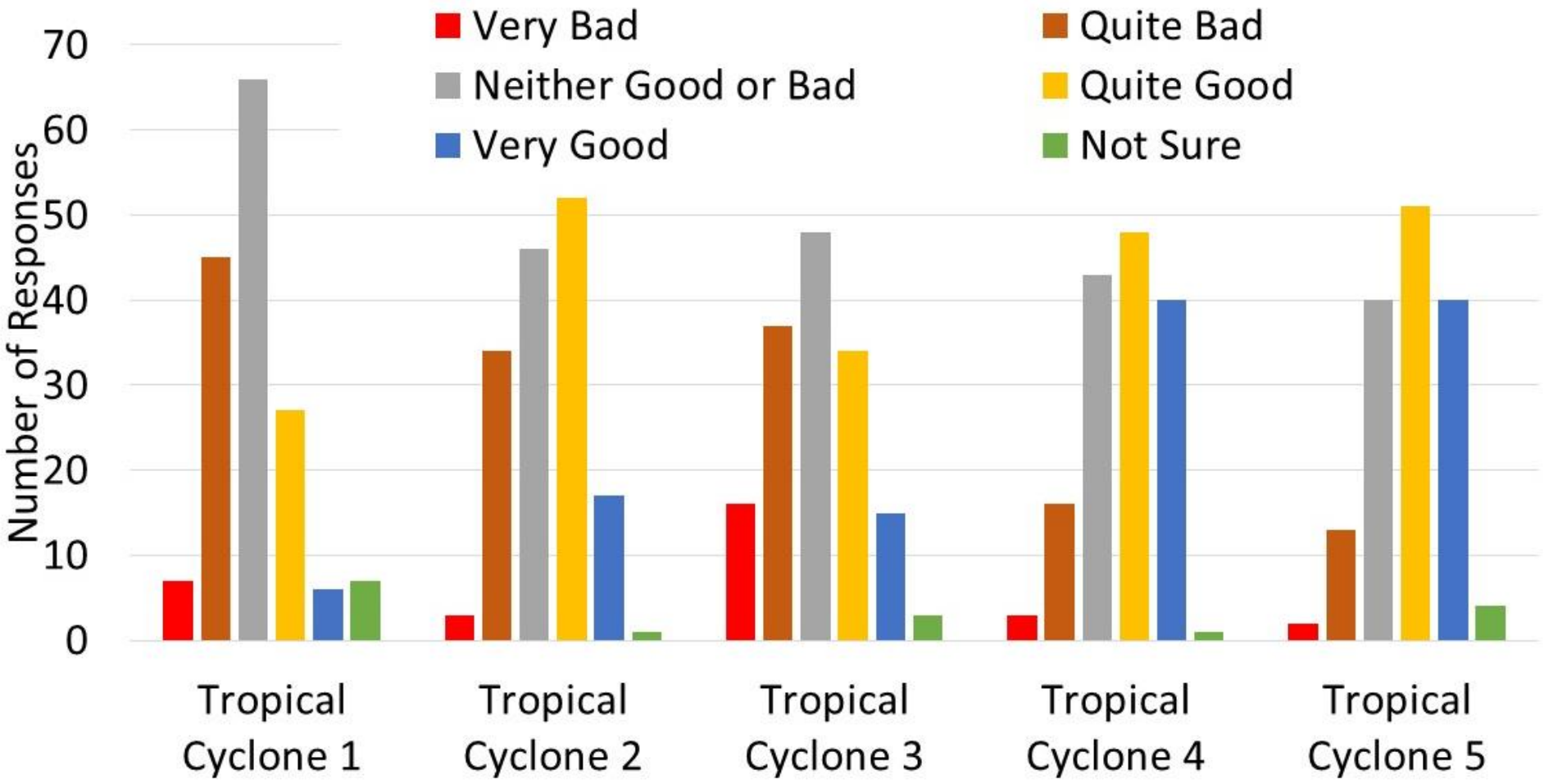


Simulated storms…with forecasts

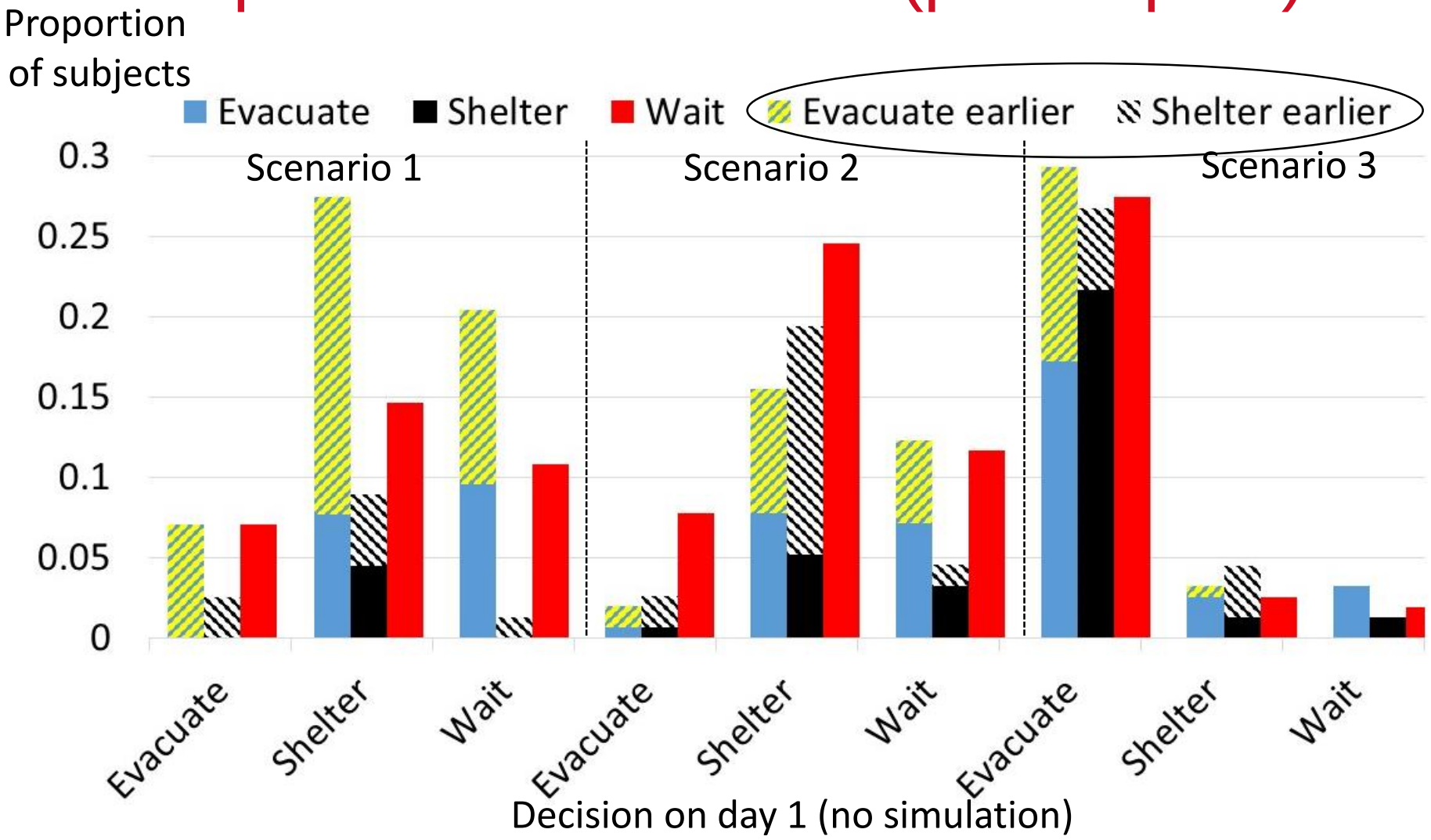
Six key decisions

and follow-on actions

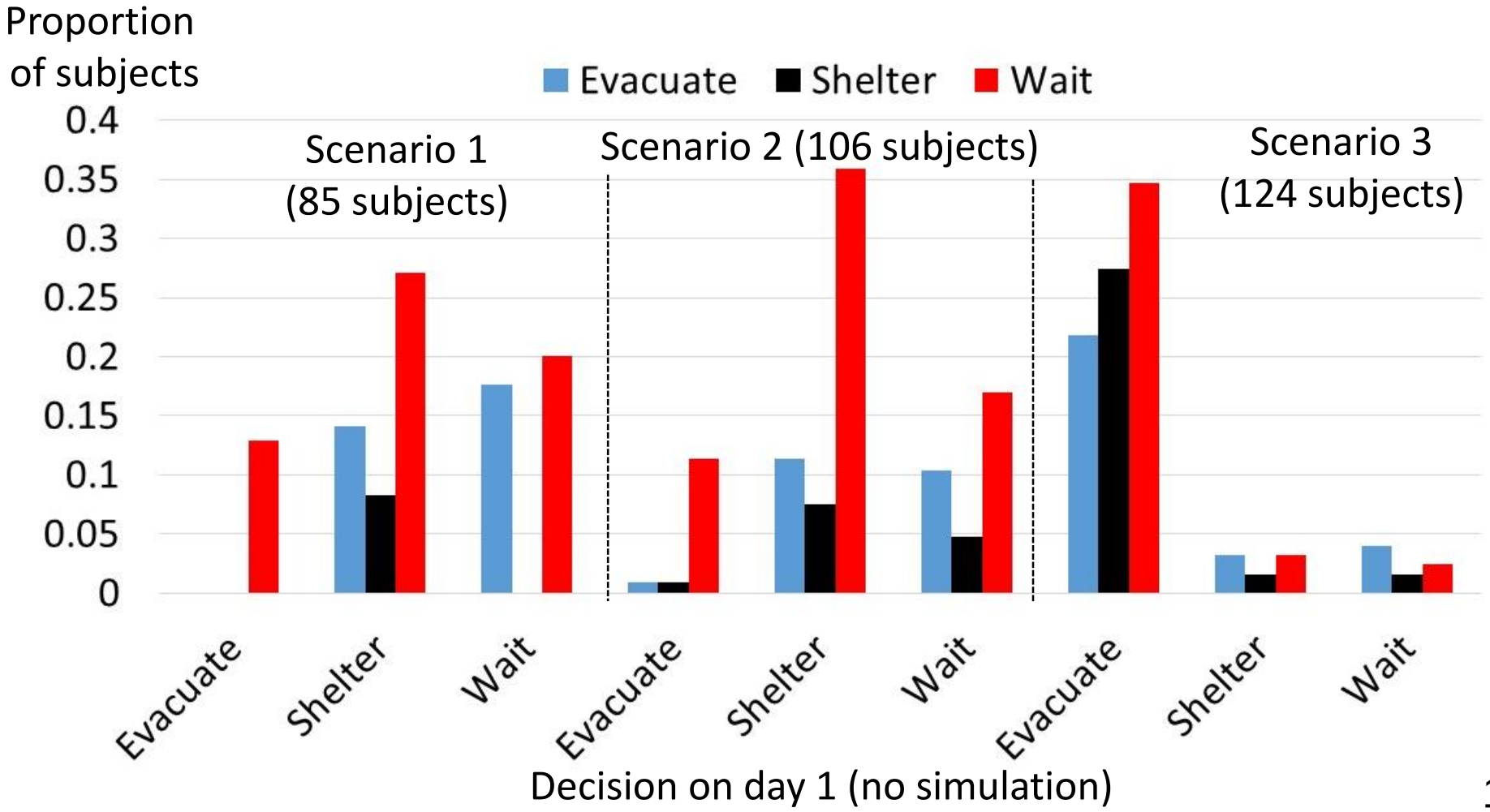
Subjective evaluation of decision-making process



Comparison of decisions (pre vs post)



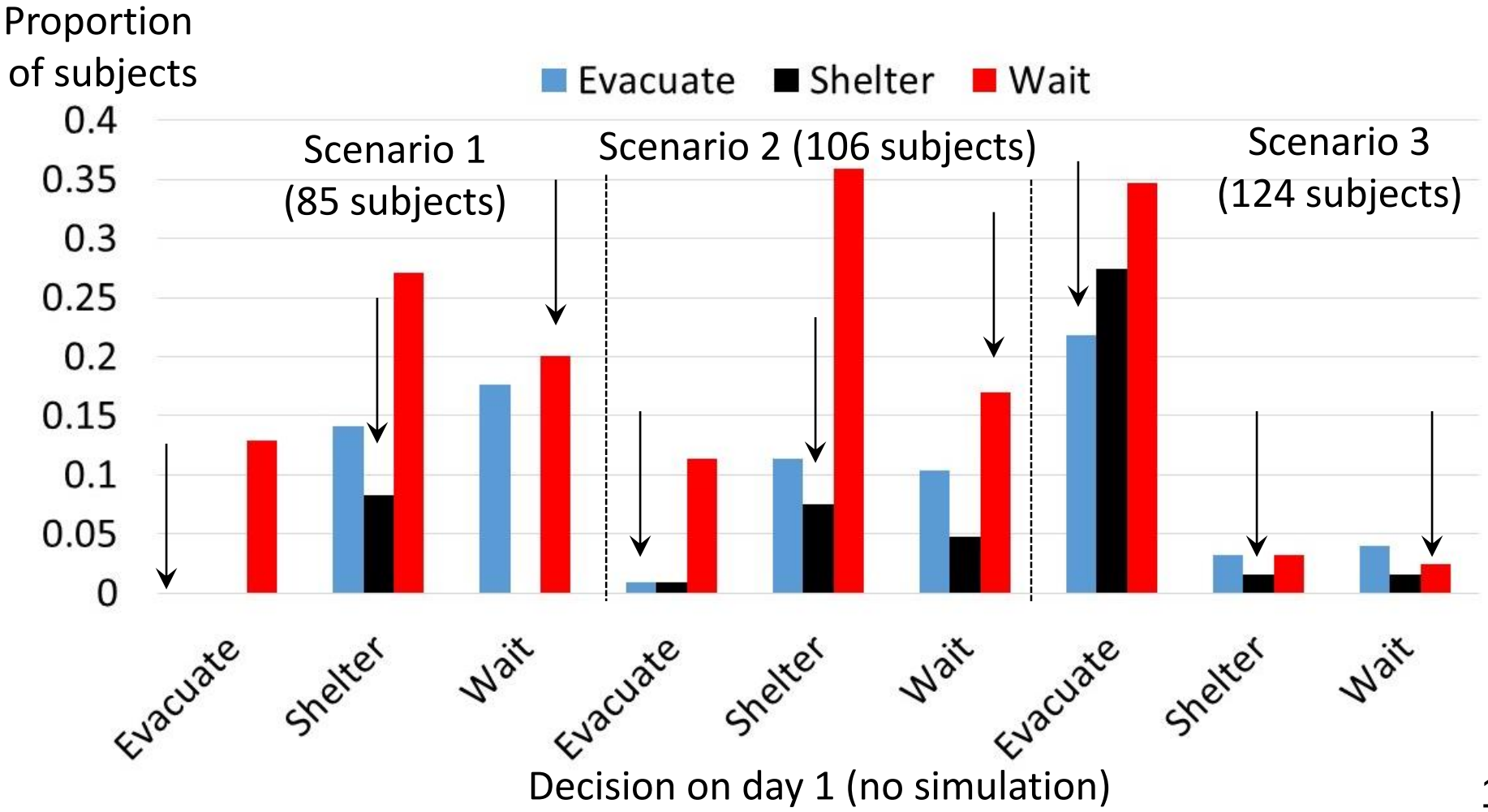
Excluding subjects who evacuate / shelter earlier



Hypothesis 1

- Subject is more likely to make a different decision when using the Hurricane Decision Simulator
- Null: probability of making same decision on days 1 and 2 equals probability of making different decision

Hypothesis 1



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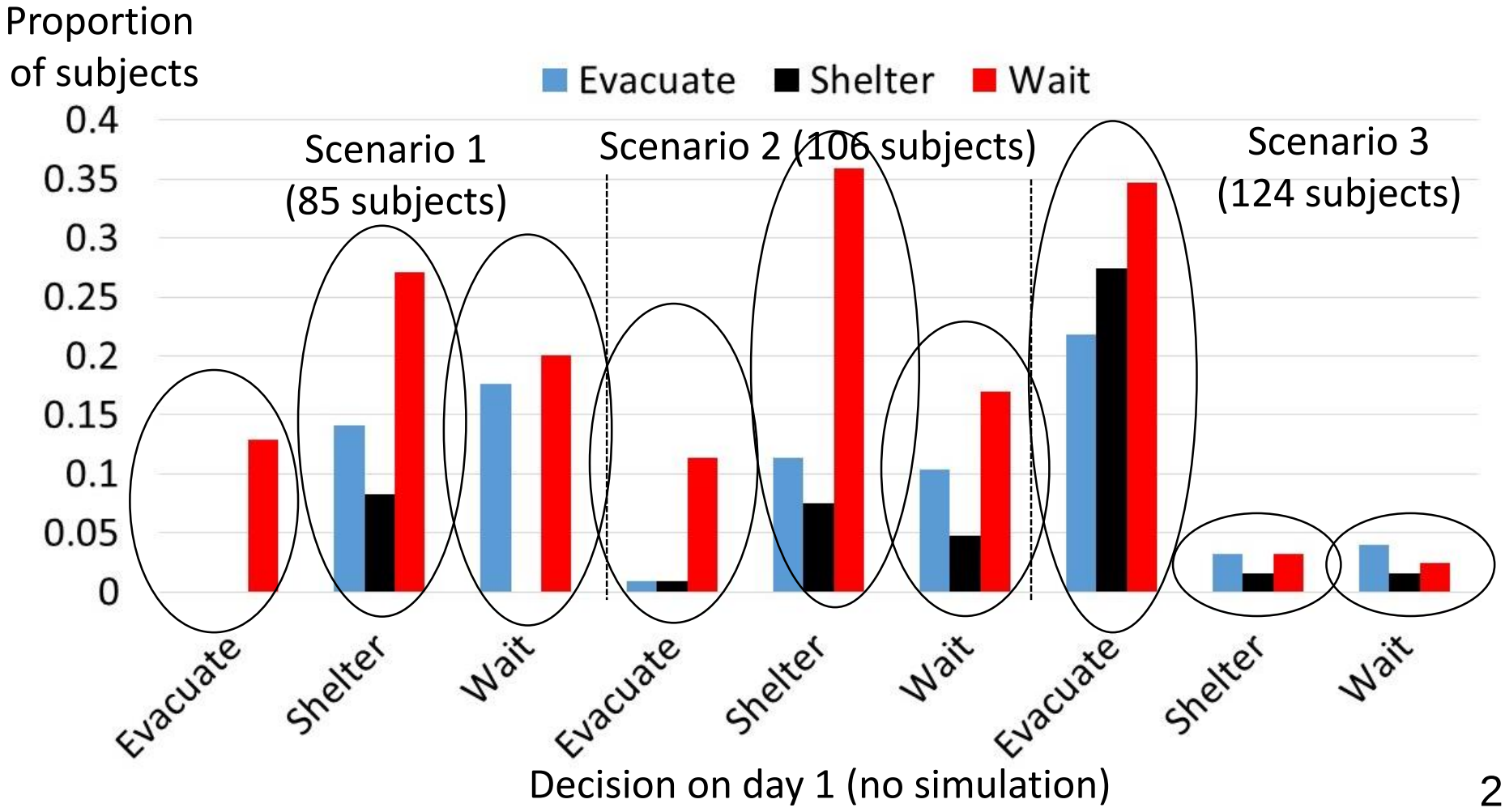
	p-value
Scenario 1	4E-06
Scenario 2	3E-06
Scenario 3	4E-10

Reject null

Hypothesis 2

- Subject more likely to switch than what random chance would predict
- Null: probability of “Evacuate” equals probability of “Shelter” equals probability of “Wait”

Hypothesis 2



Hypothesis 2 using Bayesian analysis

- Jeffrey's prior, $\mathbf{p} \sim Dirichlet(0.5)$
- Posterior, $\mathbf{p} \sim Dirichlet(0.5 + \text{number of subjects})$

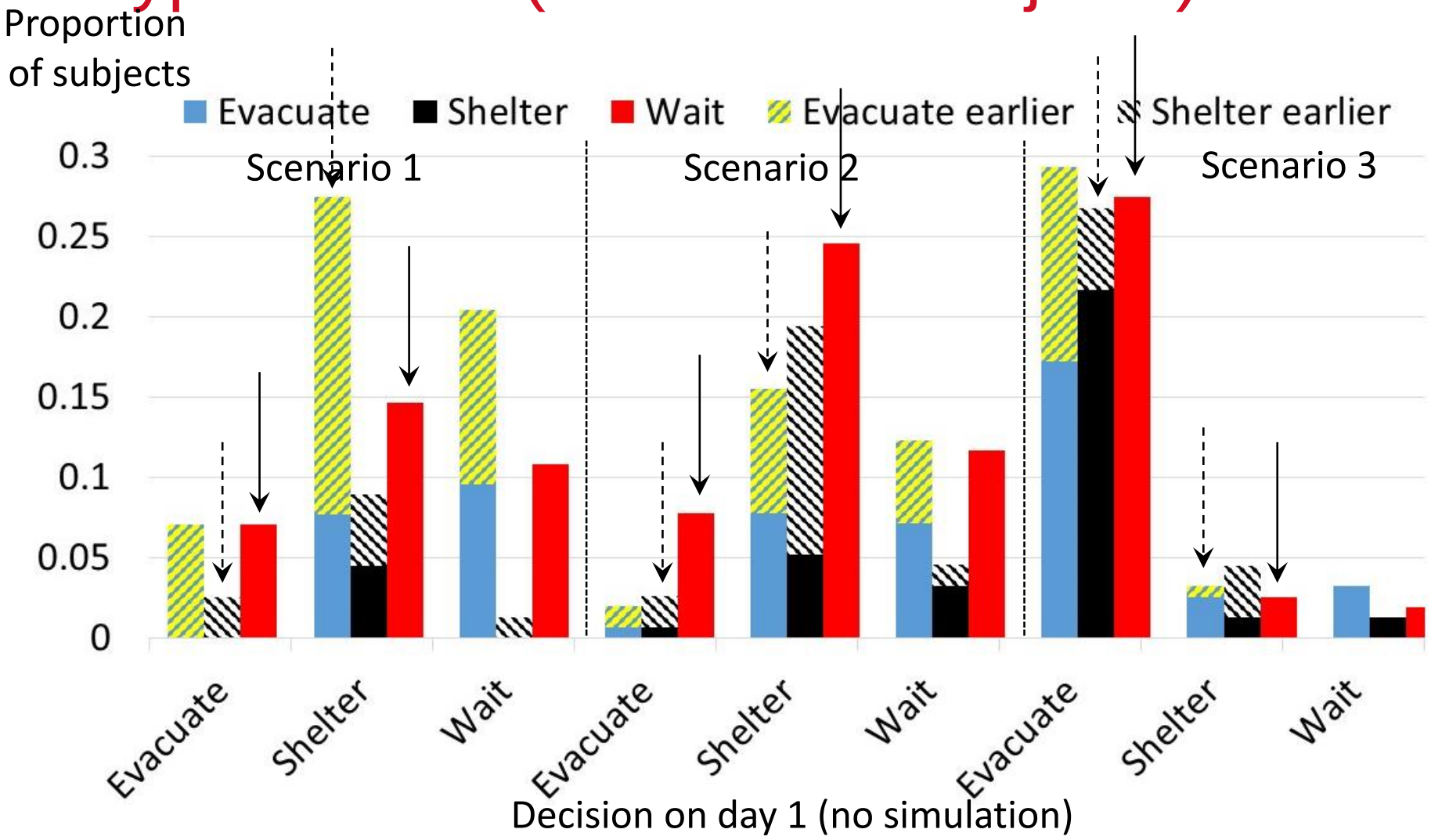
	Given day 1 decision, probability 3 decisions on day 2 are equally likely		
Day 1 decision	**Evacuate**	**Shelter**	**Wait**
Scenario 1	0	4E-4	0
Scenario 2	2E-5	0	9E-4
Scenario 3	0.01	0.11	0.07

Based on 200,000 simulations of posterior distribution

Hypothesis 3

- Given that a subject switches between days 1 and 2, more likely that a subject switches to “Wait”
- Null: probability of switching from “Evacuate” to “Shelter” or from “Shelter” to “Evacuate” equals probability of switching to “Wait”

Hypothesis 3 (data for all subjects)



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	Given evacuate on day 1, P(shelter > wait) on day 2	Given shelter on day 1, P(evacuate > wait) on day 2
Scenario 1	0.034	0.99
Scenario 2	0.021	0.038
Scenario 3	0.46	0.63

Based on 200,000 simulations of posterior distribution

Conclusions

- People that practice with the Hurricane Decision Simulator (HDS) feel more comfortable making decisions in that context
- Impact of practicing with HDS
  - People seem more likely to switch their decisions after practicing with HDS
  - Choosing decision with HDS seems more than just random chance
  - HDS may slightly influence people to wait to evacuate or shelter, especially for difficult decisions

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