Planning & Response for a New Madrid Seismic Zone Earthquake

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MoDOT Safety & Emergency Management Unit

Feb 2023 – Turkey 7.8

March 2011 – Japan 9.1

Dec 2004 – Indonesia 9.3

Largest Earthquakes by Magnitude

Rank	Magnitude[6]	Event	Location	Date
1	9.1–9.3	**2004 Indian Ocean earthquake**	Indonesia, Sumatra, Indian Ocean,	December 26, 2004
2	9.0–9.1	**2011 Tōhoku earthquake**	Japan, Tōhoku, Pacific Ocean	March 11, 2011
3	8.8	**2010 Chile earthquake**	Chile, Maule	February 27, 2010
4	8.6	**2005 Nias–Simeulue earthquake**	Indonesia, Sumatra	March 28, 2005
4	8.6	**2012 Indian Ocean earthquakes**	Indonesia, Sumatra	April 11, 2012
5	8.5	**September 2007 Sumatra earthquakes**	Indonesia, Sumatra	September 12, 2007

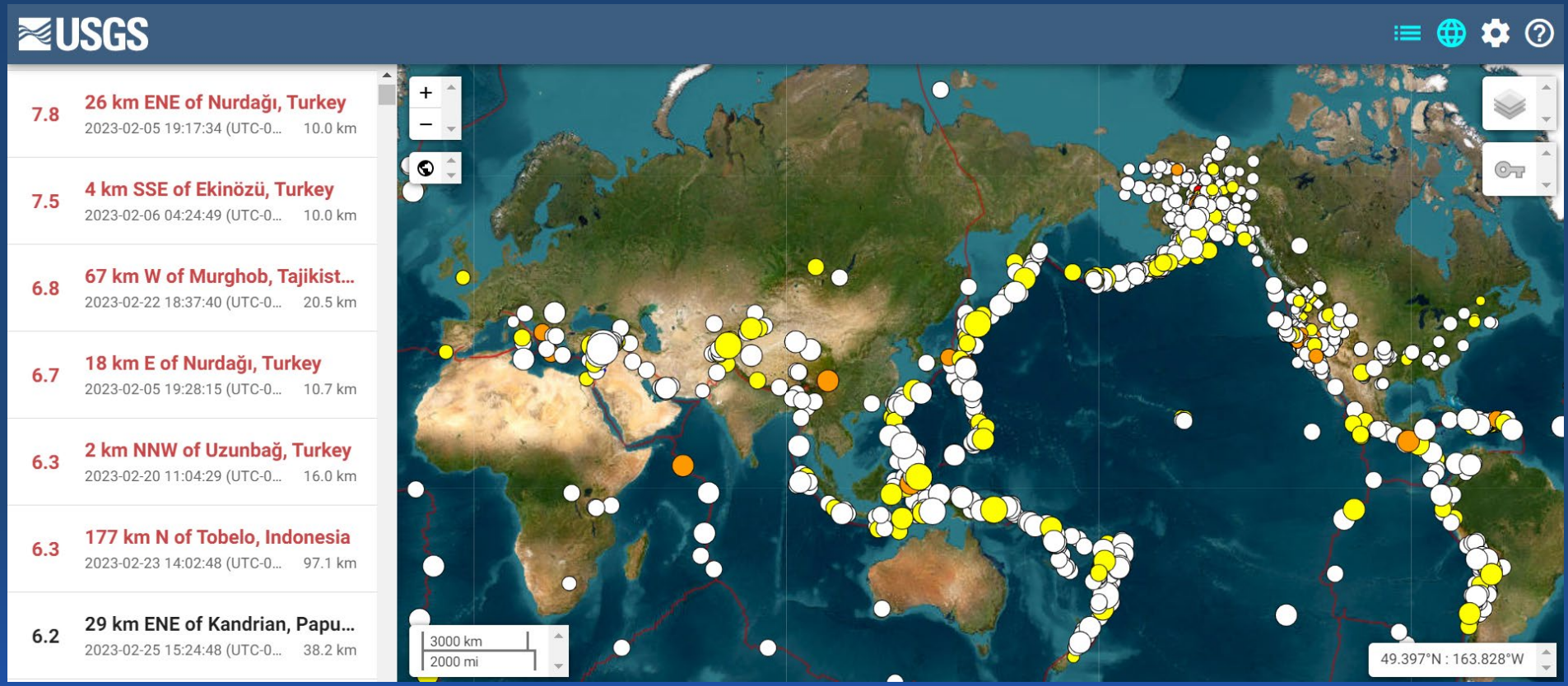
Deadliest Earthquakes

Rank	Fatalities	Magnitude	Location	Event	Date
1	227,898	9.1–9.3	Indonesia, Indian Ocean	2004 Indian Ocean earthquake and tsunami	December 26, 2004
2	160,000[3]	7.0	Haiti	2010 Haiti earthquake	January 12, 2010
3	87,587	7.9	China	2008 Sichuan earthquake	May 12, 2008
4	87,351	7.6	India, Pakistan	2005 Kashmir earthquake	October 8, 2005
5	51,130	7.8	Turkey, Syria	2023 Turkey–Syria earthquake	February 6, 2023
6	34,000[4]	6.6	Iran	2003 Bam earthquake	December 26, 2003
7	20,085	7.7	India	2001 Gujarat earthquake	January 26, 2001
8	19,759	9.0–9.1	Japan	2011 Tōhoku earthquake and tsunami	March 11, 2011
9	8,964	7.8	Nepal	2015 Nepal earthquake	April 25, 2015
10	5,782	6.4	Indonesia	2006 Yogyakarta earthquake	May 26, 2006

Costliest Earthquakes

Rank	Damage $Billions	Magnitude	Event	Location	Date
1	$360	9.0–9.1	2011 Tōhoku earthquake and tsunami	Japan	March 11, 2011
2	$150	7.9	2008 Sichuan earthquake	China	May 12, 2008
3	$84.1[7]	7.8	2023 Turkey–Syria earthquake	Turkey Syria	February 6, 2023
4	$40	6.1	2011 Christchurch earthquake	New Zealand	February 22, 2011
5	$40	7.0	2010 Canterbury earthquake	New Zealand	September 4, 2010
6	$28	6.8	2004 Chūetsu earthquake	Japan	October 23, 2004
7	$22.3	6.9	2011 Sikkim earthquake	India	September 18, 2011
8	$20	7.0	2016 Kumamoto earthquakes	Japan	April 15, 2016
9	$16	6.3	2009 L'Aquila earthquake	Italy	April 6, 2009
10	$15.8	5.8	2012 Emilia earthquake	Italy	May 20, 2012
11	$15–$30	8.8	2010 Chile earthquake	Chile	February 27, 2010

Earthquakes Last 30 Days



Nov 2022 – Indonesia 5.6

1811-1812 New Madrid Earthquakes

- December 16, 1811, Northeast Arkansas - 2:15 am
  Magnitude 7.5 (first main shock)

- December 16, 1811, Northeast Arkansas - 7:15 am
  Magnitude 7.0 (the “dawn" aftershock)

- January 23, 1812, New Madrid, Missouri - 9:15 am
  Magnitude 7.3 (second principal shock)

- February 7, 1812, New Madrid, Missouri - 3:45 am
  Magnitude 7.5 (along Reelfoot fault in MO and TN)

1811-1812 New Madrid Earthquakes

- At least three additional large aftershocks are inferred from historical accounts on December 16 and 17
- These three events were believed to range between 6.0 and 6.5 and located in Arkansas and Missouri
- This would make a total of seven earthquakes of magnitude 6.0–7.5 occurring from December 16, 1811 through February 7, 1812

Facts (SEMA SEOP)

- This is a no-notice event impacting multiple states
- The ability to gain access to impacted areas will be limited
- A large number of evacuees will require shelter
- Information demand is extensive, but situational awareness is limited
- Building damage is extensive with large numbers of trapped individuals
- Widespread liquefaction damage will amplify impacts
- Flooding will occur due to liquefaction and waterway infrastructure failures
- Casualties will be significant and include medically-complicated survivors
- Aftershocks will extend the response and recovery phases
- Aged, unreinforced masonry buildings and structures are common
- Seasonal weather conditions affect every aspect of response and recovery
- There will be long term impacts to all infrastructure sectors

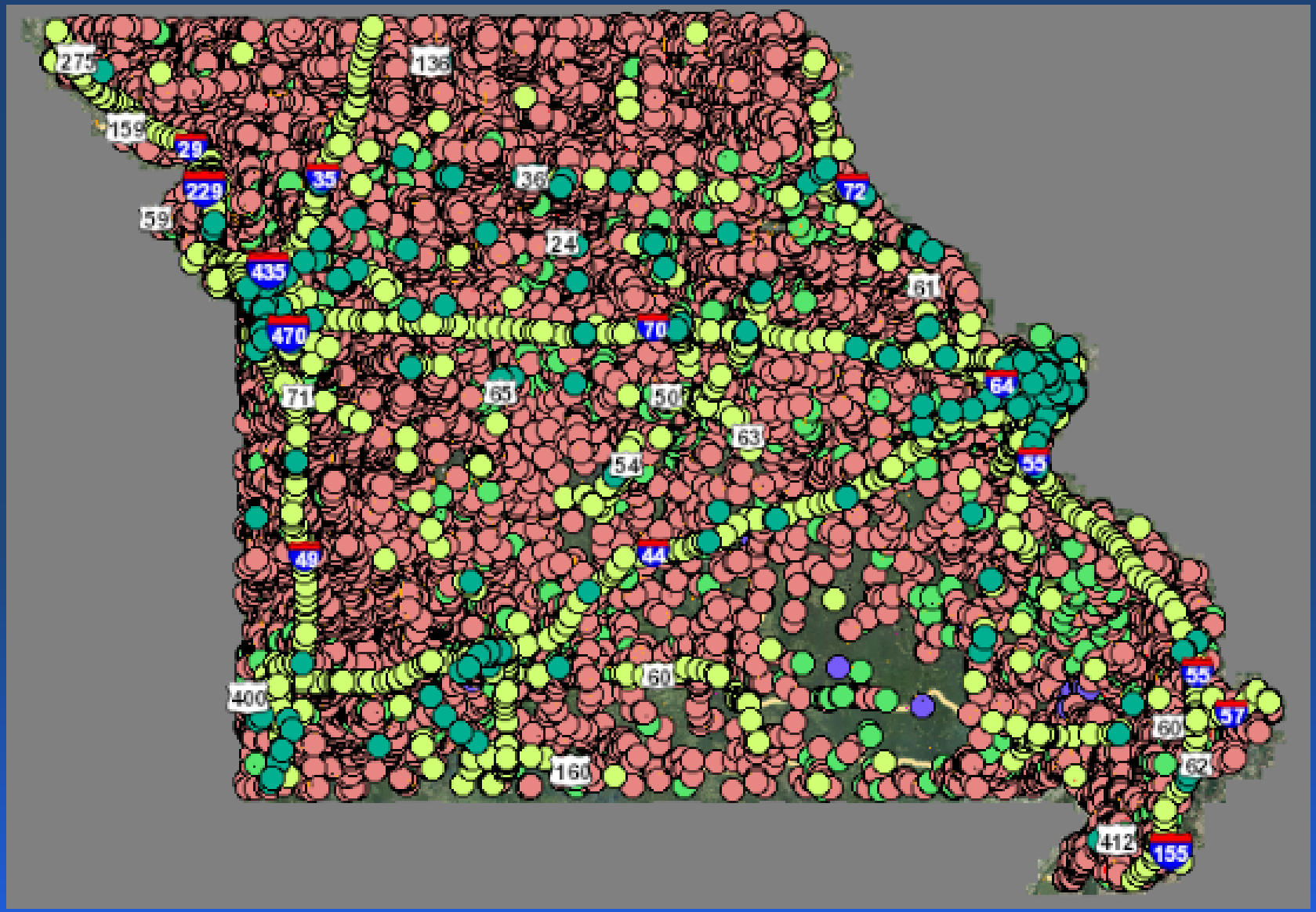
Assumptions (SEMA SEOP)

- Governor immediately declares State of Emergency and requests federal declaration
- The President will declare a major disaster, making federal assistance available
- Energy and transportation sectors may require support from neighboring states
- The State Emergency Operations Center is not damaged and is fully operational
- Ongoing multiple disasters elsewhere in the country also require resources
- Large scale evacuations, both organized and self-directed, occur
- Immediate support is required to save lives and mitigate damage to property
- Families are separated from each other, including parents from children
- FEMA will be required to adjudicate resource distribution to impacted states
- HAZMAT releases are extensive, response need exceeds available capability
- Large scale evacuation, self-evacuation, and sheltering exceeds capabilities

Estimated Damage to Roads/Bridges

- **2009 MAE Center Volume II data summarized impacts within the 22 highest-impacted Missouri counties:**
  - 1,004 bridges damaged or destroyed
  - 28 airports destroyed
  - 6.5 million tons of debris created
  - 842,002 individuals displaced

Bridges


275
136
159
29
229
35
72
59
24
435
61
470
70
71
65
50
64
63
54
55
49
44
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55
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400
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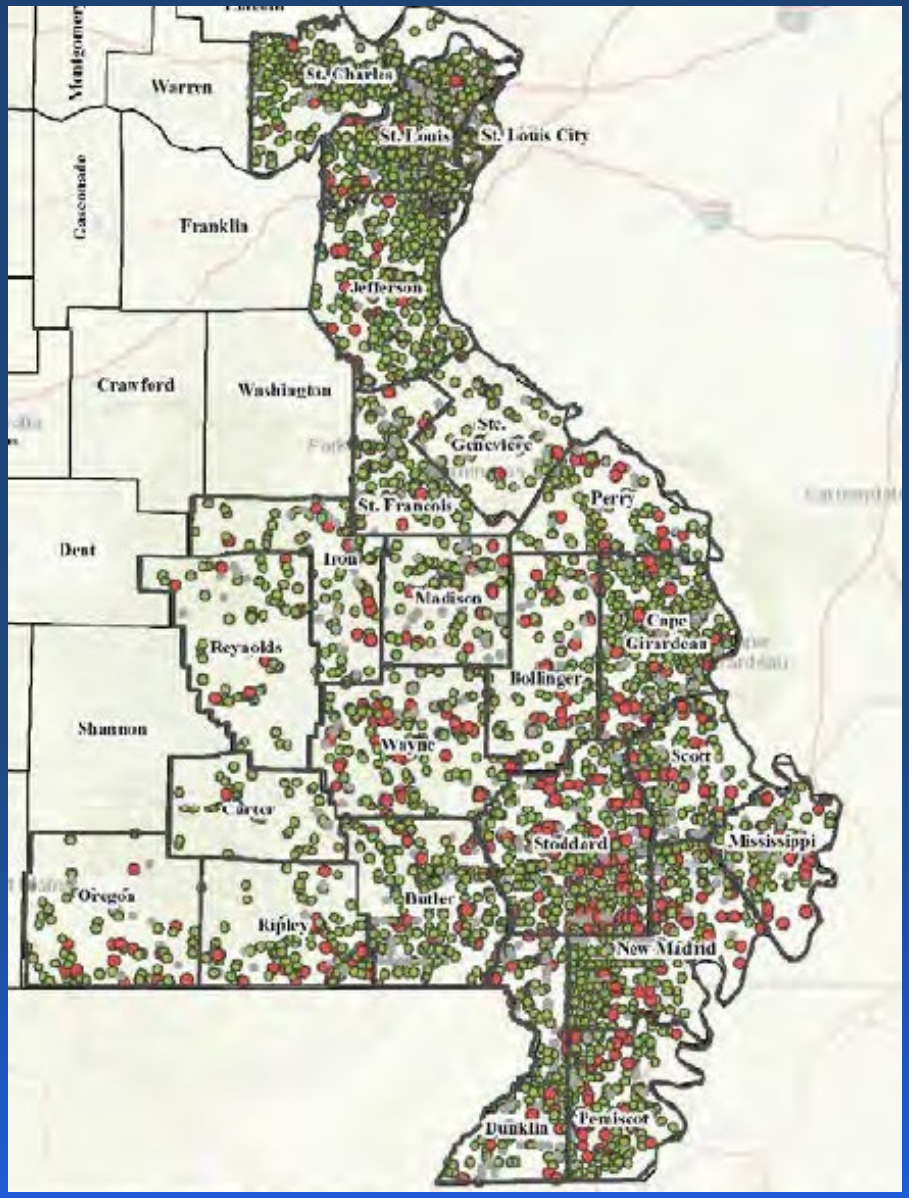
62
160
412
155

Bridges


Warren
St. Charles
St. Louis
St. Louis City
Franklin
Jefferson
Crawford
Washington
Ste. Genevieve
St. Francois
Perry
Dent
Iron
Madison
Cape Girardeau
Reynolds
Bollinger
Shannon
Wayne
Scott
Carter
Stoddard
Mississippi
Oregon
Butler
Ripley
New Madrid
Dunklin
Pemiscot

State of Missouri Department of Transportation

ShakeCast Report

National Earthquake Information Center (NEIC)

Magnitude 7.5 - Commerce_RLME

Version 5

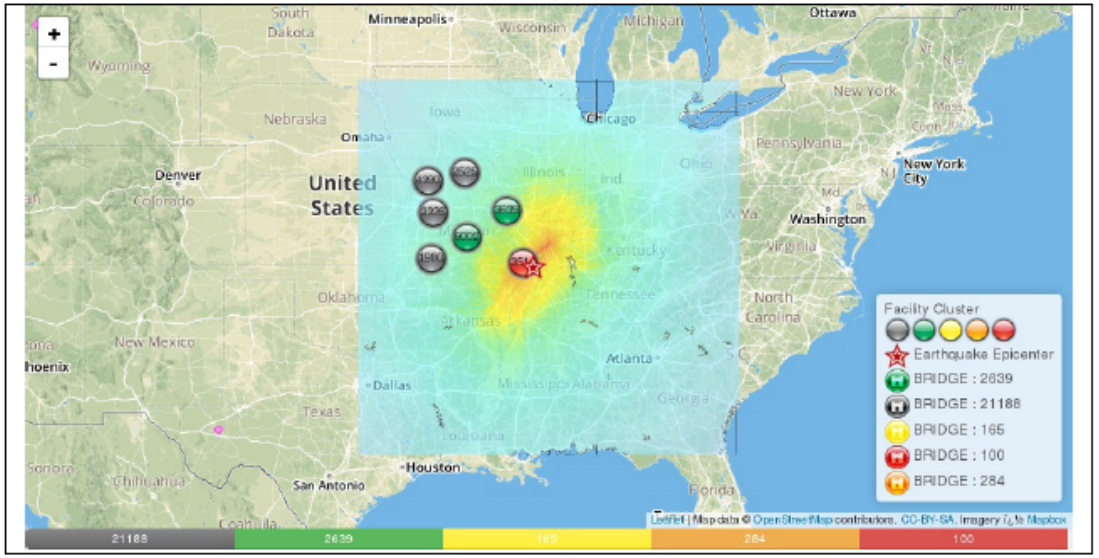
Origin Time: 2017-05-12 18:52:32 GMT

Created: 2018-07-24 18:14:56 GMT

Latitude: 36.94254 Longitude: -89.73817

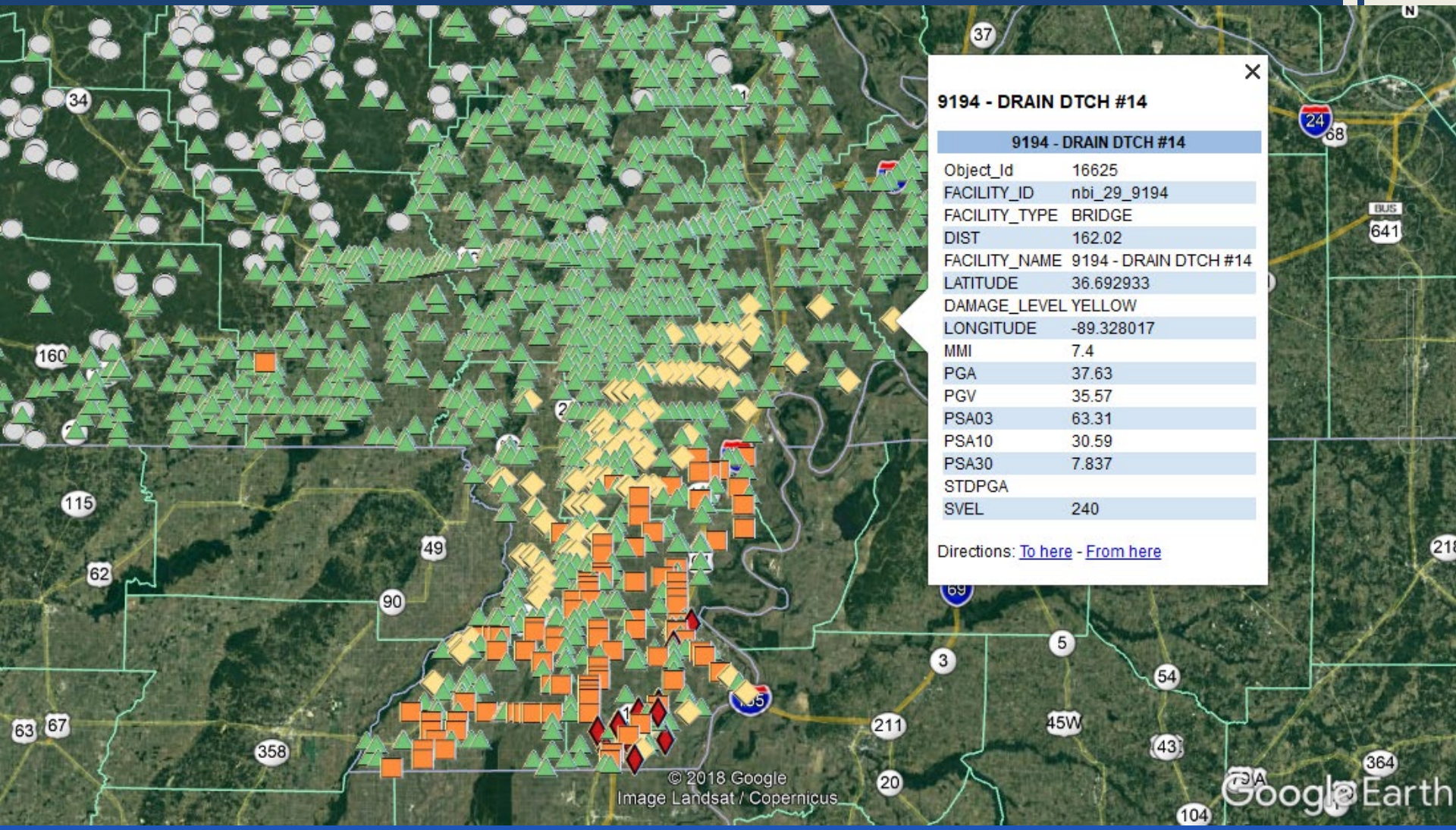
Depth: 19.6455 km

These results are from an automated system and users should consider the preliminary nature of this information when making decisions relating to public safety. ShakeCast results are often updated as additional or more accurate earthquake information is reported or derived.



Type	ID	Name	Ep. Distance (km)	Inspection Priority	PGA (%g)	PGV (cm/s)	PSA 1s (%g)	MMI	Vs30 (m/s)
BRIDGE	29_14360	14360 - WAHITE DRAIN DTCH	2.78	High	80.95	76.06	71.96	VIII	
BRIDGE	29_8169	8169 - DRAIN DTCH #35	2.97	High	80.21	74.15	70.21	VIII	
BRIDGE	29_14561	14561 - DRAIN DTCH	3.42	High	75.91	74.66	70.73	VIII	
BRIDGE	29_14577	14577 - LITTLE RVR	5.14	High	63.97	68.38	65.07	VII	
BRIDGE	29_16539	16539 - DRAIN DTCH NO 2	5.81	High	77.33	74.37	70.45	VIII	
BRIDGE	29_6967	6967 - DRAIN DTCH #24	5.95	High	85.26	80.81	76.26	VIII	
BRIDGE	29_16563	16563 - LITTLE RVR	6.04	High	83.81	82.87	78.17	VIII	
BRIDGE	29_16478	16478 - DTCH NO 2	6.1	High	82.15	79.41	75.01	VIII	
BRIDGE	29_9829	9829 - DRAIN DTCH #37	6.36	High	84.45	82.03	77.38	VIII	
BRIDGE	29_16617	16617 - DTCH NO 1	7.26	High	82.18	78.83	74.47	VIII	
BRIDGE	29_16504	16504 - DTCH NO 1	7.59	High	77.2	77.86	73.63	VIII	
BRIDGE	29_16463	16463 - DTCH NO 2	8.12	High	83.99	83.35	78.62	VIII	
BRIDGE	29_6165	6165 - DRAIN DTCH 1 DIST	8.53	High	79.95	80.73	76.26	VIII	
BRIDGE	29_15781	15781 - ANGLE DRAIN DTCH	9.52	High	86.12	84.62	79.75	VIII	
BRIDGE	29_6190	6190 - DRAIN DTCH 2 DIST	9.55	High	84.21	82.82	78.12	VIII	
BRIDGE	29_6166	6166 - DRAIN DTCH 4 DIST	9.88	High	83.02	82.37	77.71	VIII	

* MMI level may extend beyond map boundary; some facilities may not appear on the map due to space restriction


9194 - DRAIN DTCH #14
9194 - DRAIN DTCH #14
Object_Id 16625
FACILITY_ID nbi_29_9194
FACILITY_TYPE BRIDGE
DIST 162.02
FACILITY_NAME 9194 - DRAIN DTCH #14
LATITUDE 36.692933
DAMAGE_LEVEL YELLOW
LONGITUDE -89.328017
MMI 7.4
PGA 37.63
PGV 35.57
PSA03 63.31
PSA10 30.59
PSA30 7.837
STDPGA
SVEL 240
Directions: To here - From here
© 2018 Google
Image Landsat / Copernicus
Google Earth

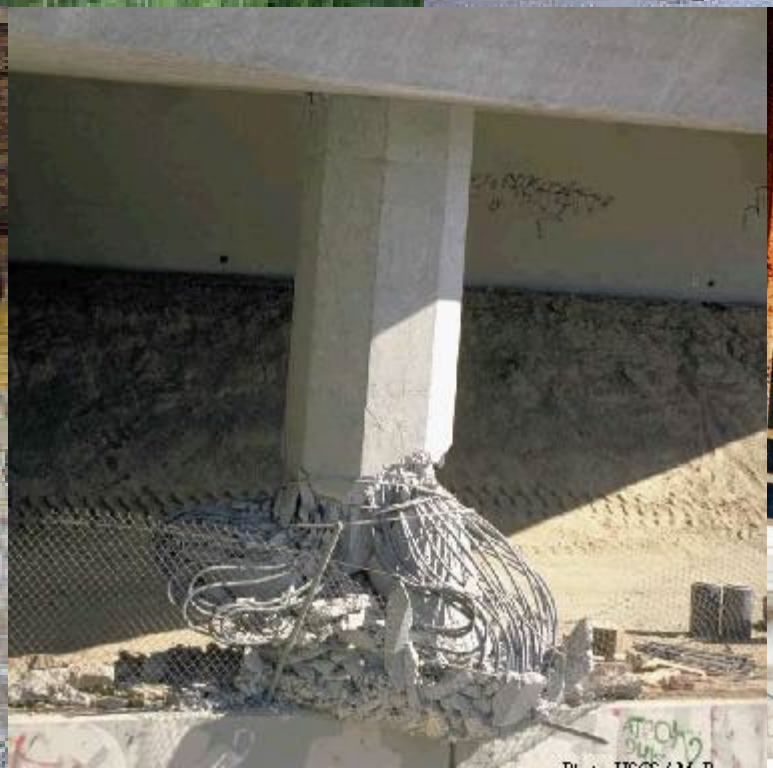
Regional Response Objectives

- Activate regional response plans
- Establish communications
- Begin road & bridge assessments
- Conduct emergency debris clearance operations
- Initiate regional re-routing plans
- Determine status of other transportation modes

Assessing Transportation Status

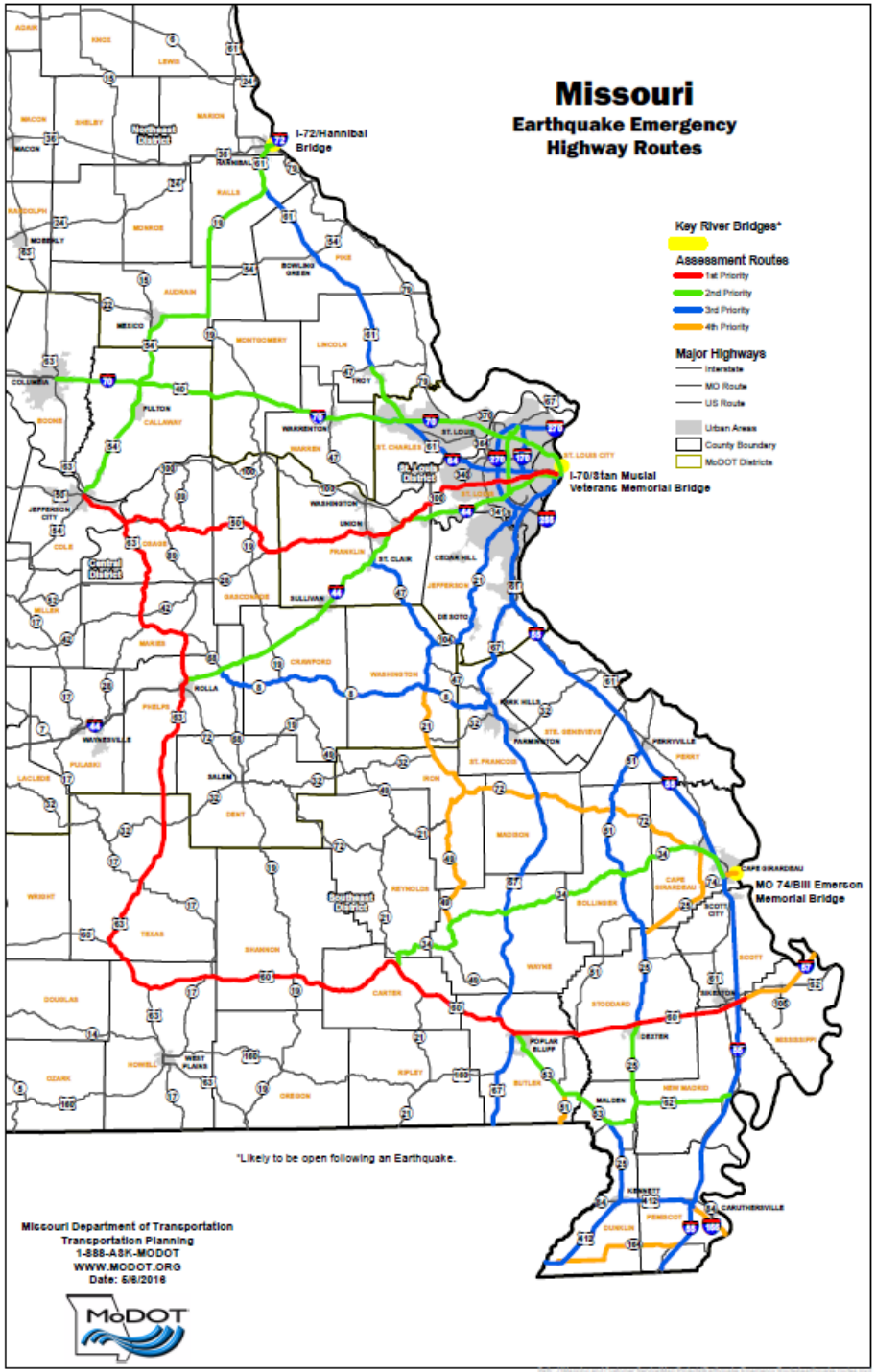
- **Utilize any available status information**
  - MoDOT inspection team reports
  - External source reports (MONG, MSHP, EMD's)
  - Social media postings (if available)

- **Generate GIS situation status map**
  - MoDOT Traveler Information Map layer
  - MoDOT Emergency Status Map layer
  - Other agency status layers



Ingress/Egress

- **Pre-determined emergency routes detailed in plan**
  - 4 levels of inspection priority
  - Highest likelihood of viability
  - Least number of bridge crossings


Missouri
Earthquake Emergency
Highway Routes
I-72/Hannibal Bridge
I-70/Stan Musial Veterans Memorial Bridge
MO 74/Bill Emerson Memorial Bridge
Key River Bridges*
Assessment Routes
1st Priority
2nd Priority
3rd Priority
4th Priority
Major Highways
Interstate
MO Route
US Route
Urban Areas
County Boundary
MoDOT Districts
*Likely to be open following an Earthquake.
Missouri Department of Transportation
Transportation Planning
1-888-ASK-MODOT
WWW.MODOT.ORG
Date: 6/8/2016
MoDOT

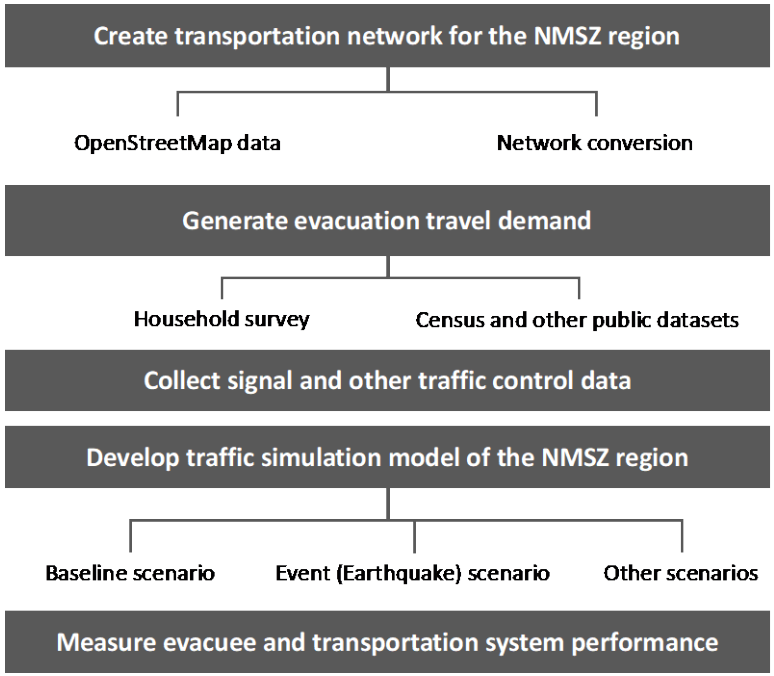
Responder & Evacuee Movement

- Model potential traffic flow of evacuees/responders
- Coordinate route management and mass care plans
- Determine roadway limitations
- Analyze use options for available routes
- Determine alternative transportation options

Earthquake Evacuation Modeling of New Madrid Region

Project Objectives

- Assess evacuation performance using simulation models
- Identify potential bottlenecks in the road network
- Estimate delays on major evacuation routes



Project Tasks

- Identify vulnerable links in the road network
  - MoDOT data and Other data (e.g., National Bridge Inventory Data)
  - Bridge Seismic Screening Tools
  - USGS ShakeMap and ShakeCast Data
- Identify alternative routes for each Origin-Destinations
- Conduct household surveys to capture evacuee behavior
- Explore different resolutions of traffic simulation models

Household Survey

Household Survey

Purpose

- To obtain evacuation-related decisions
  - stay/evacuate
  - destination choice
  - route choice
- Demand generation models will be estimated using survey responses

Survey Administration

- SE survey was open from Jan 28 - Feb 21, 2022
  - 891 responses received
- STL survey was open from Oct 6 - Nov 30, 2022
  - 194 responses received

Closings And Delays

Researchers ask southeast Mo. residents to fill out earthquake survey

The Missouri Department of Transportation and the University of Missouri are studying ways that people would try to leave the Bootheel after a major quake. (KWCH)

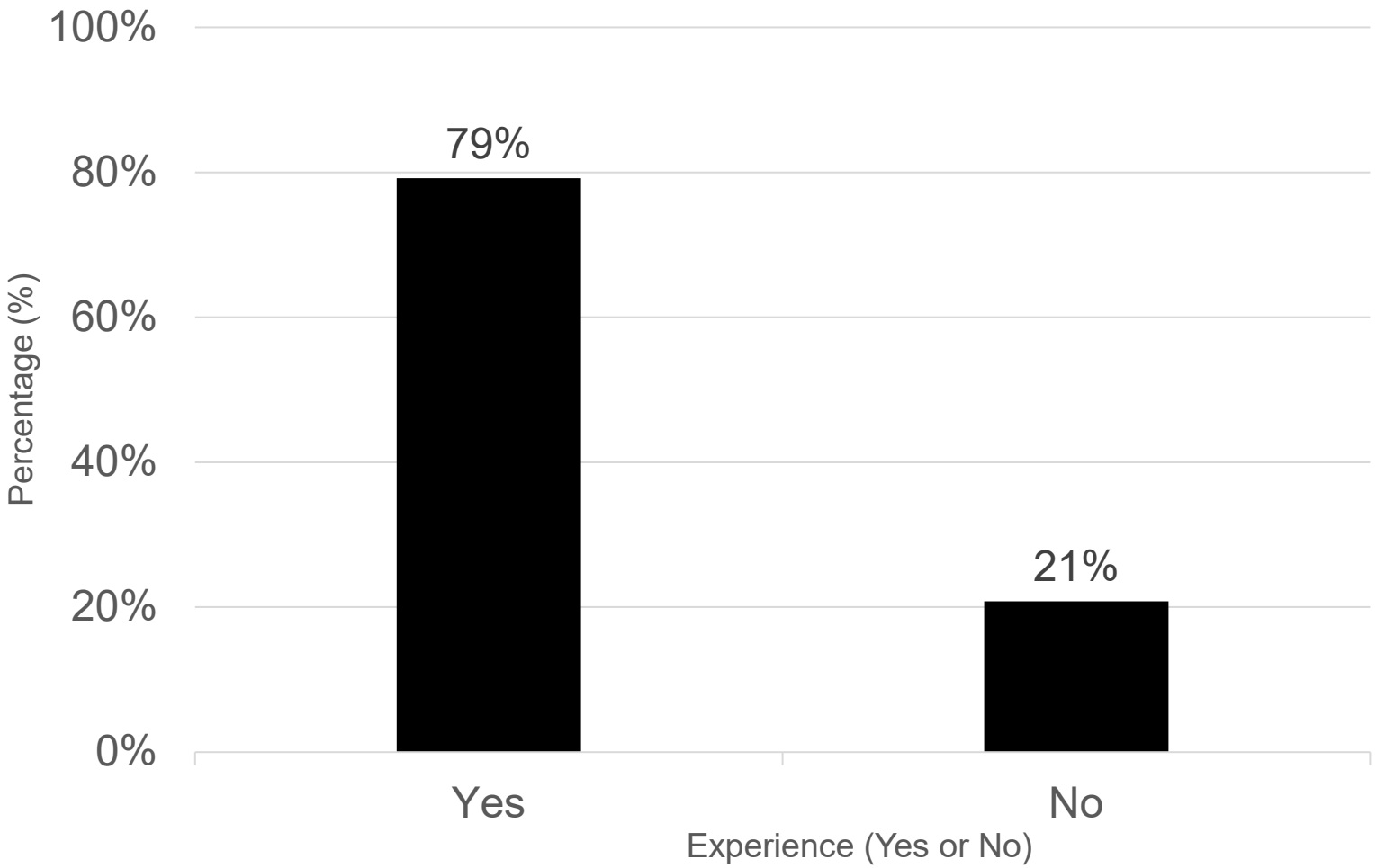
By Amber Ruch

Published: Jan. 28, 2022 at 4:12 PM CST

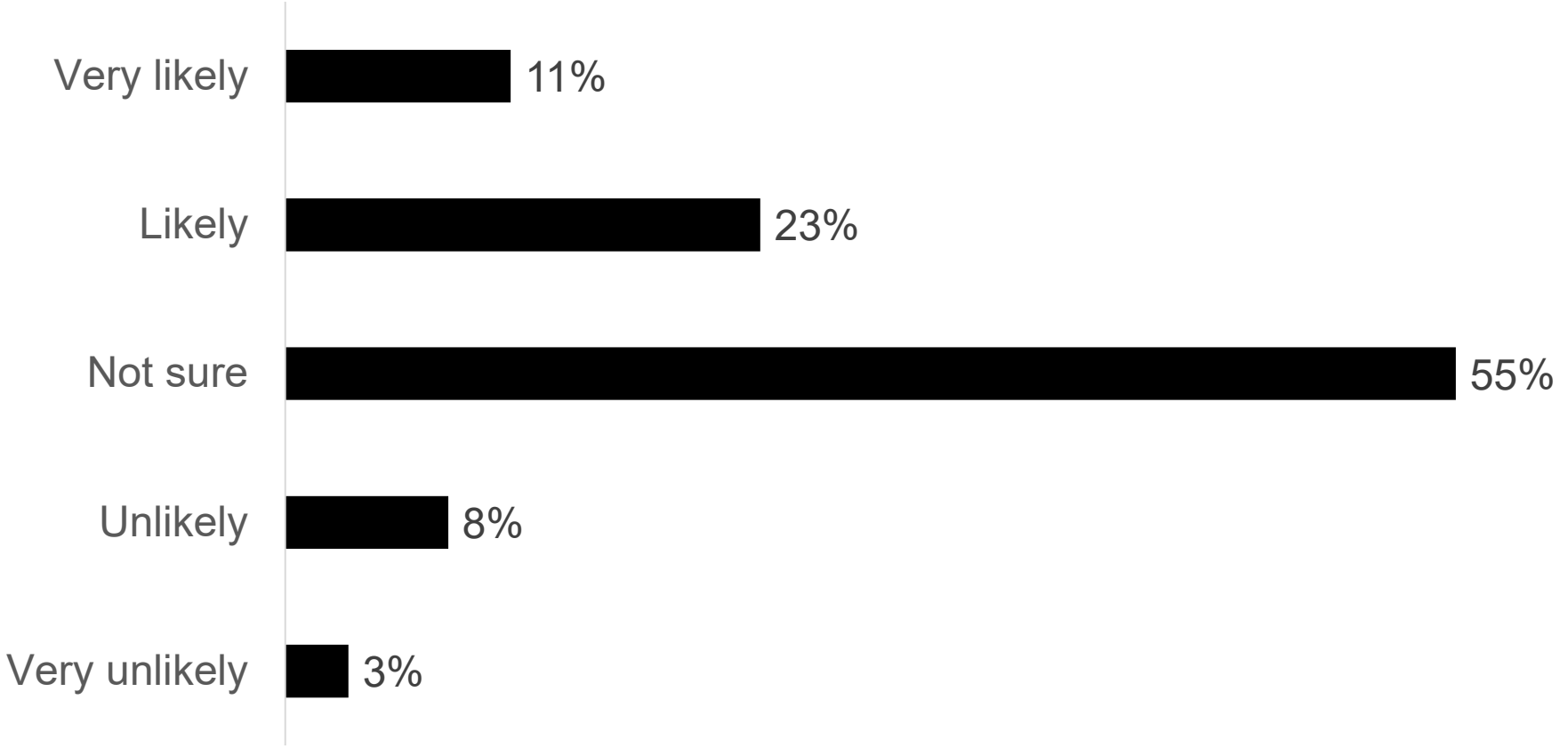
SOUTHEAST Mo. (KFVS) - Researchers want to understand what could happen after a major earthquake in the Bootheel.

What would you do after a major earthquake on the New Madrid Fault?

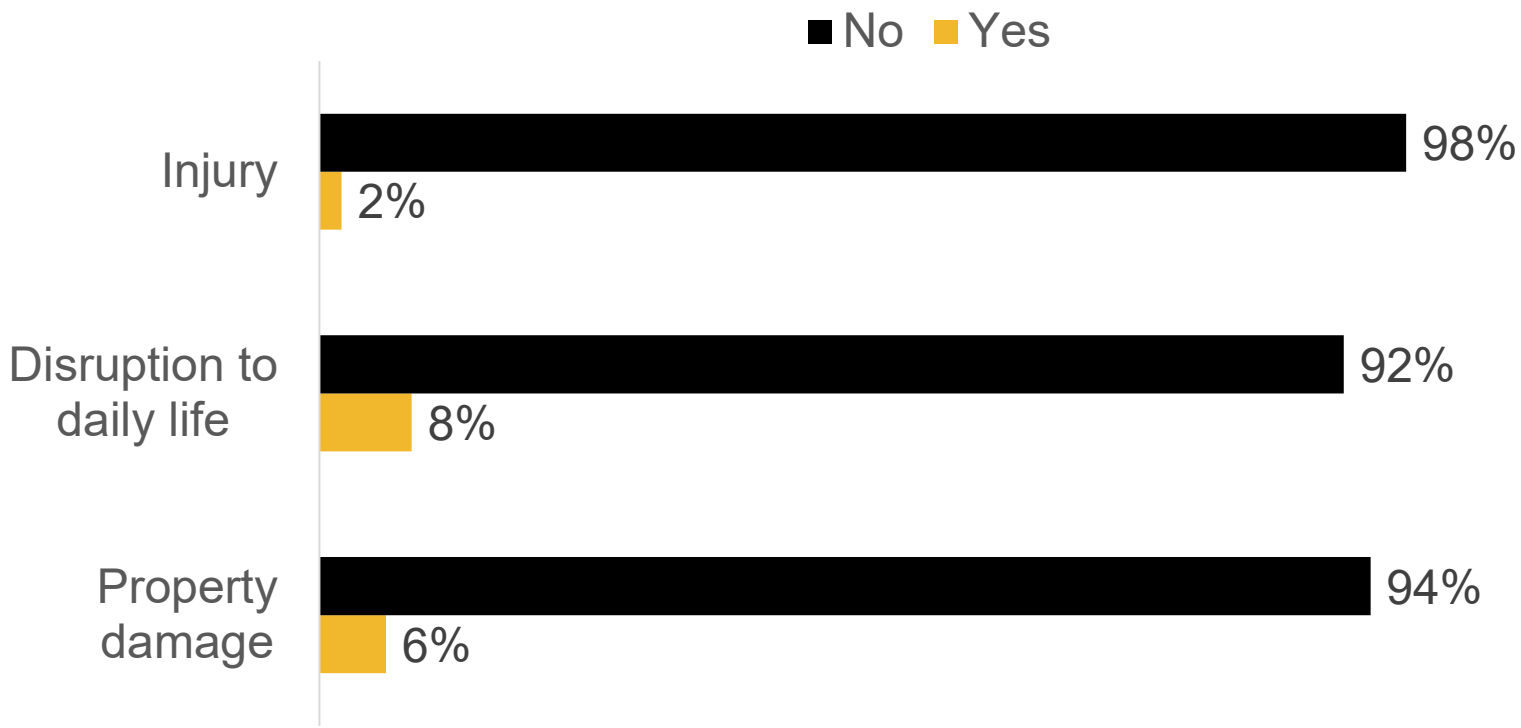
Q3. Have you ever experienced an earthquake? (N= 879)



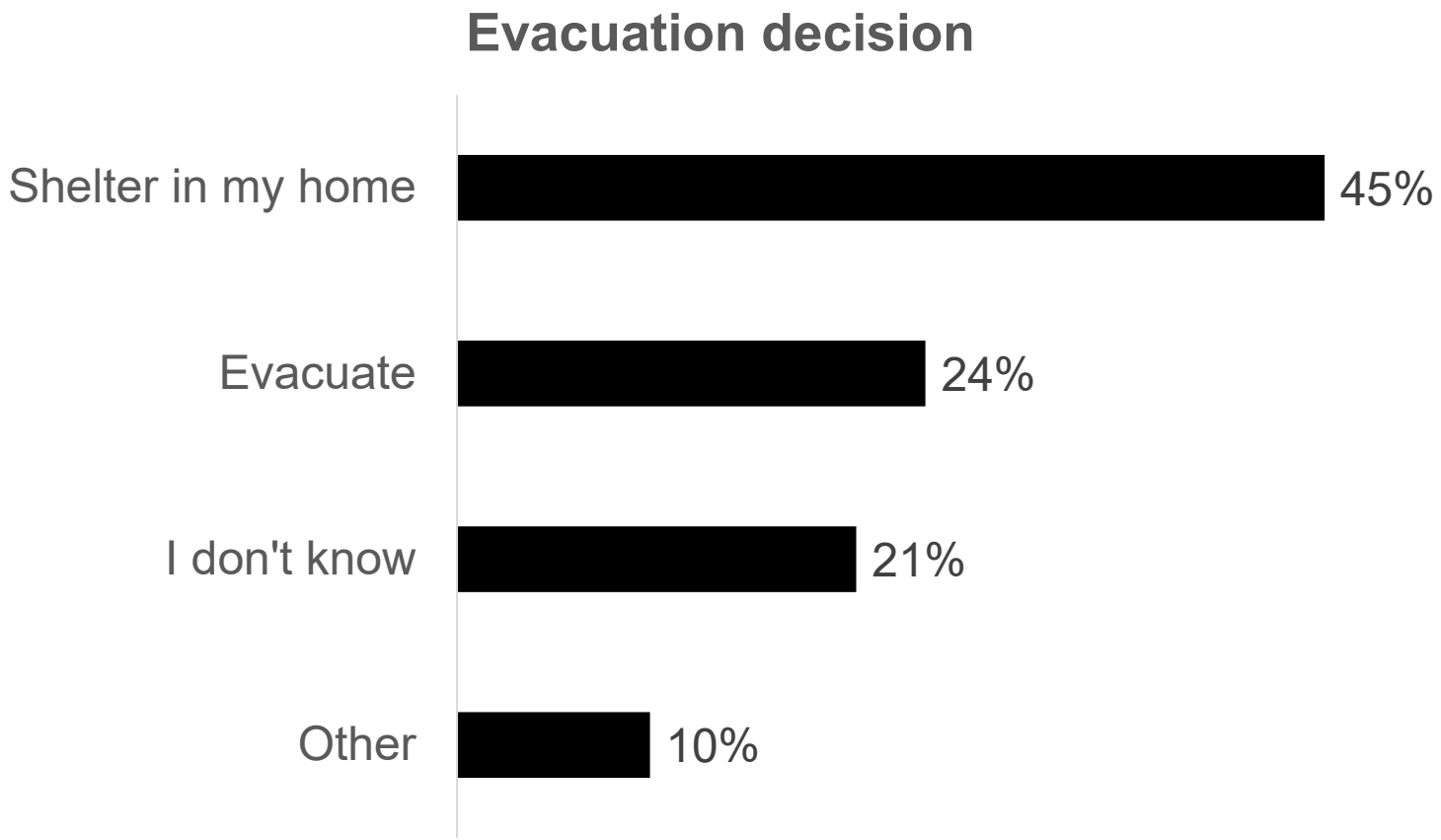
Q2. How likely is that you and your family will be impacted by an earthquake in the next five years? (N= 880)



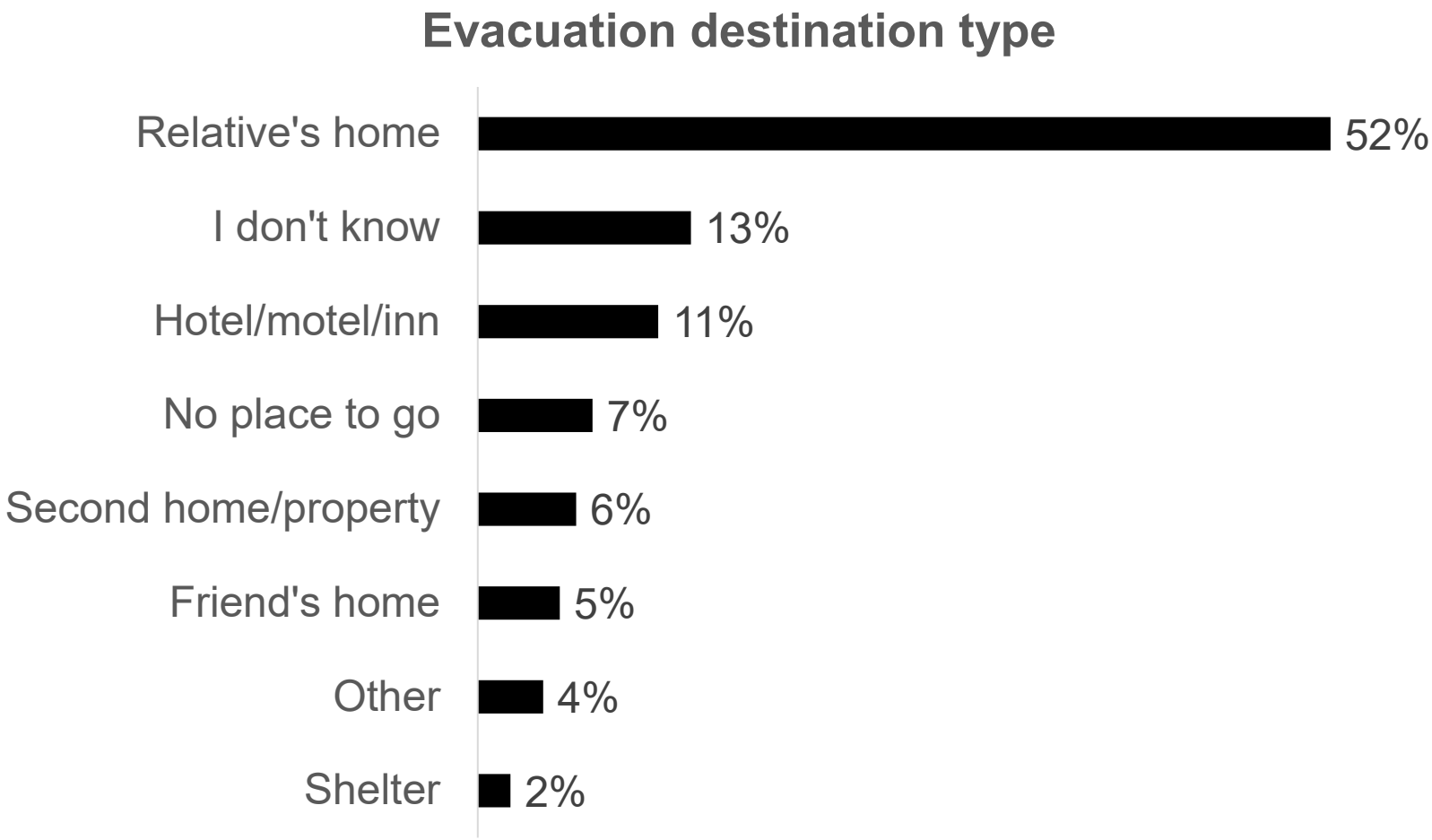
Q4. If you have experienced an earthquake before, did you have any of the following happen to you? (N= 790)



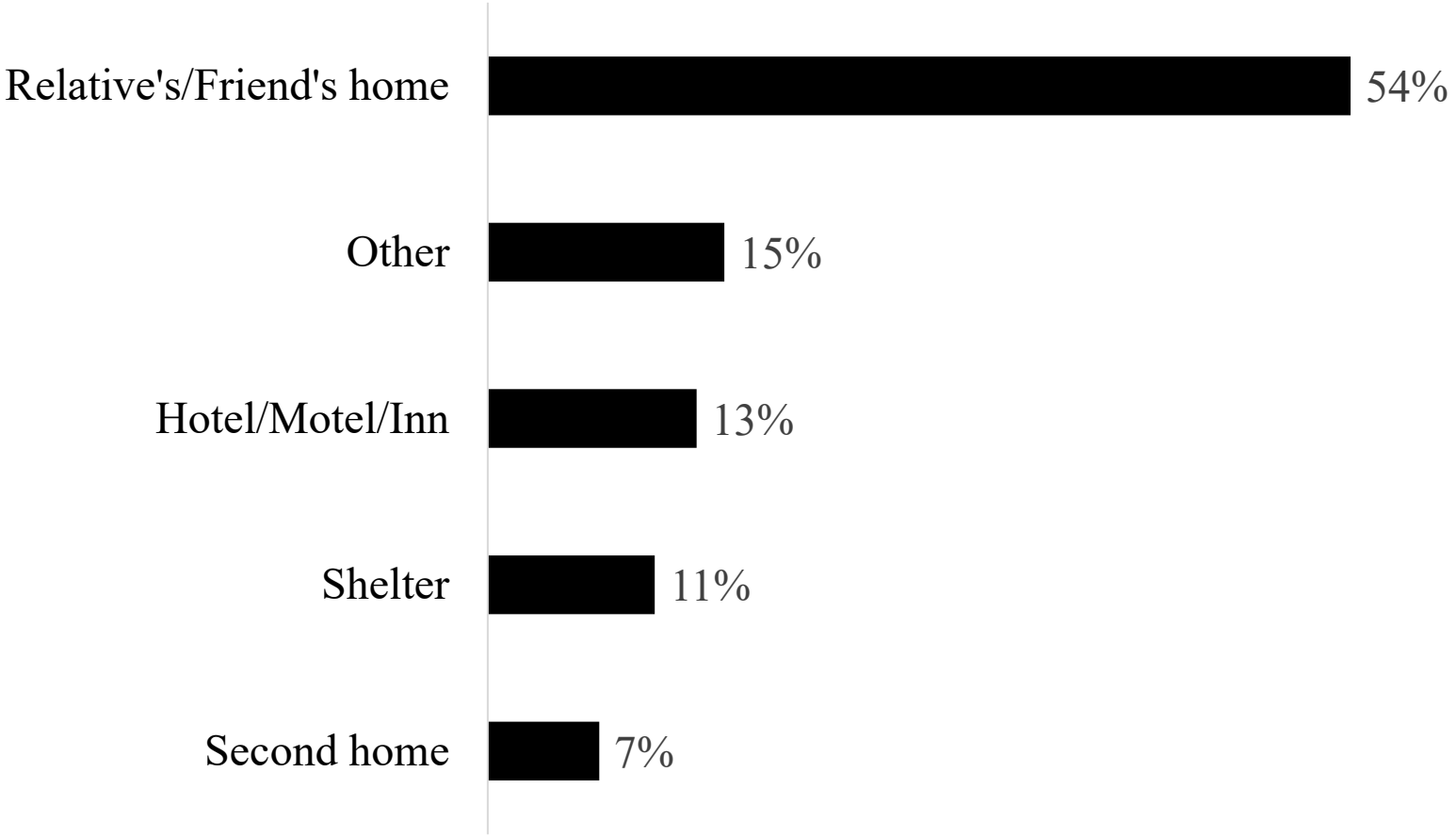
Q5. If an earthquake was going to impact your neighborhood, what would you be most likely to do? (N= 880)



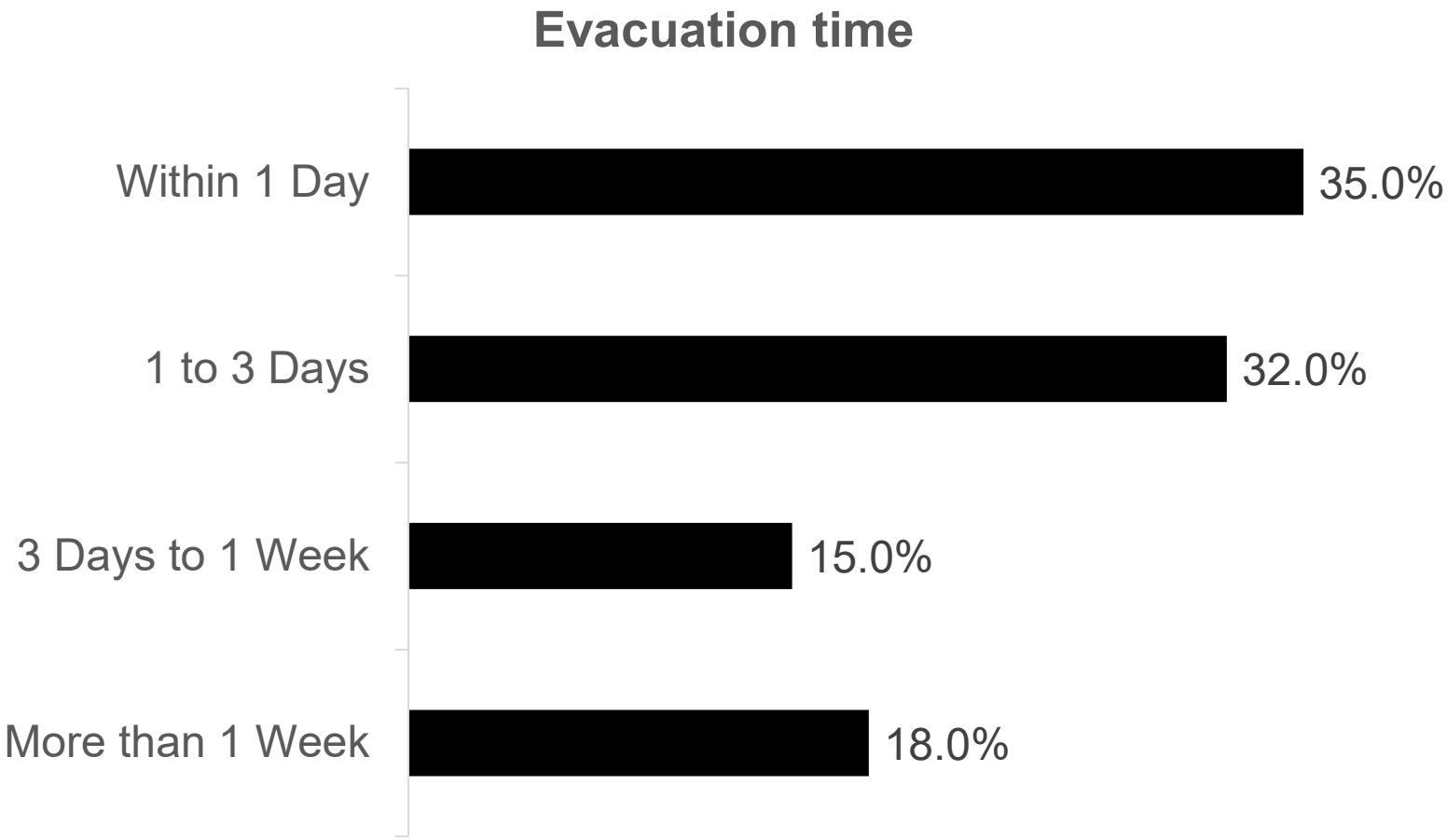
Q6. What kind of place would you go to? (N= 655)



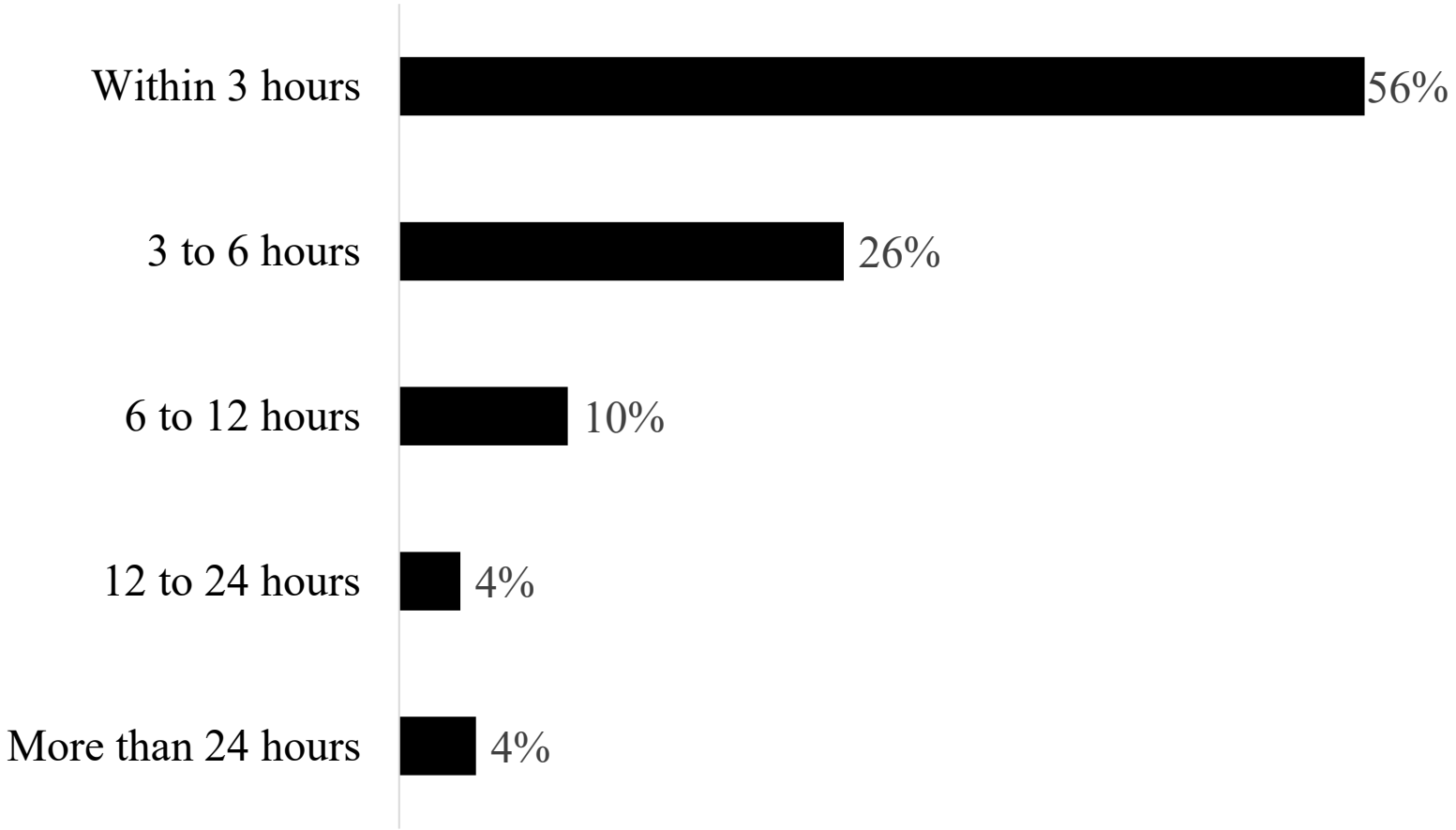
Q. Where would you go to? (N=114)



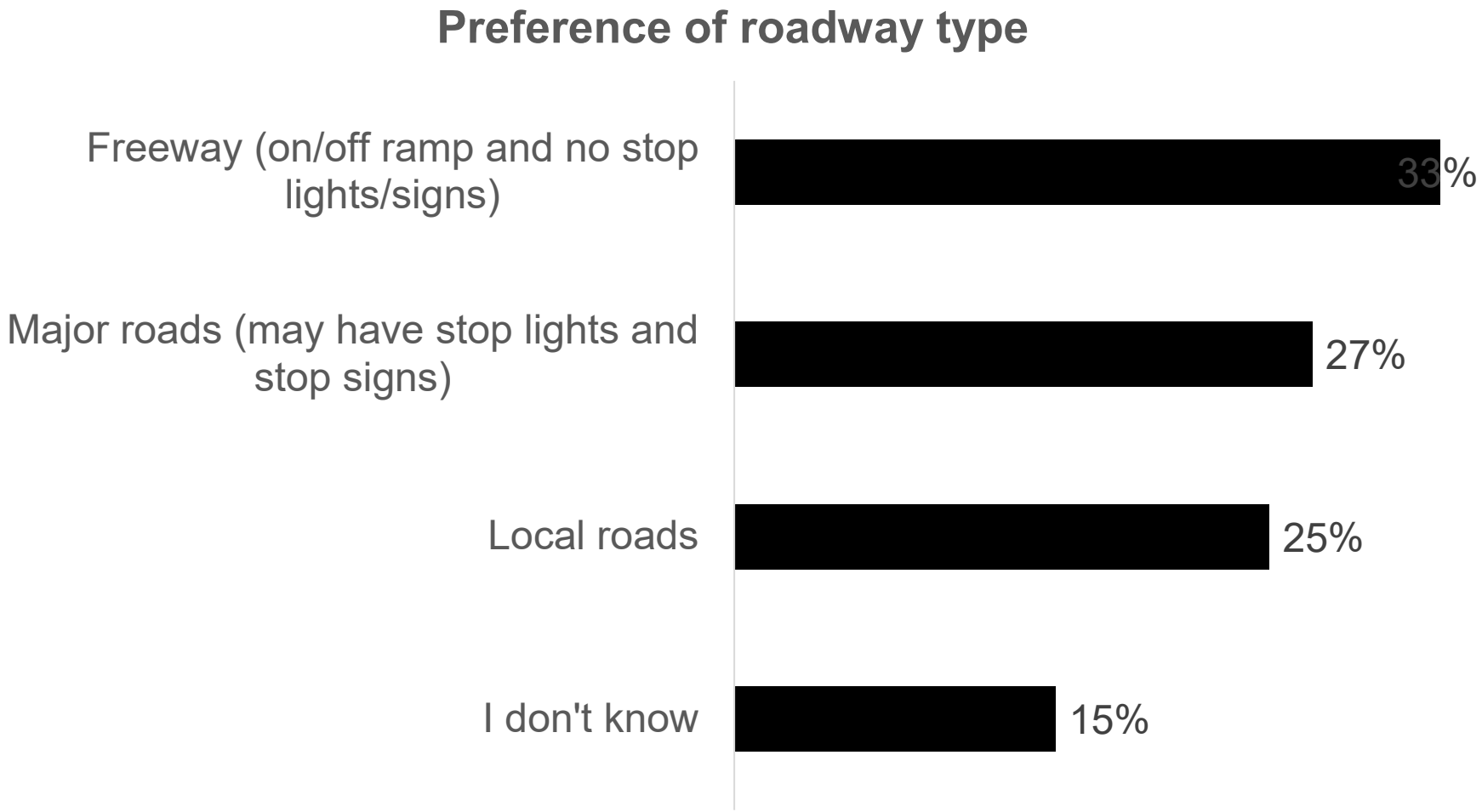
Q7. When do you think you would be most likely to leave to your destination after an earthquake? (N= 636)



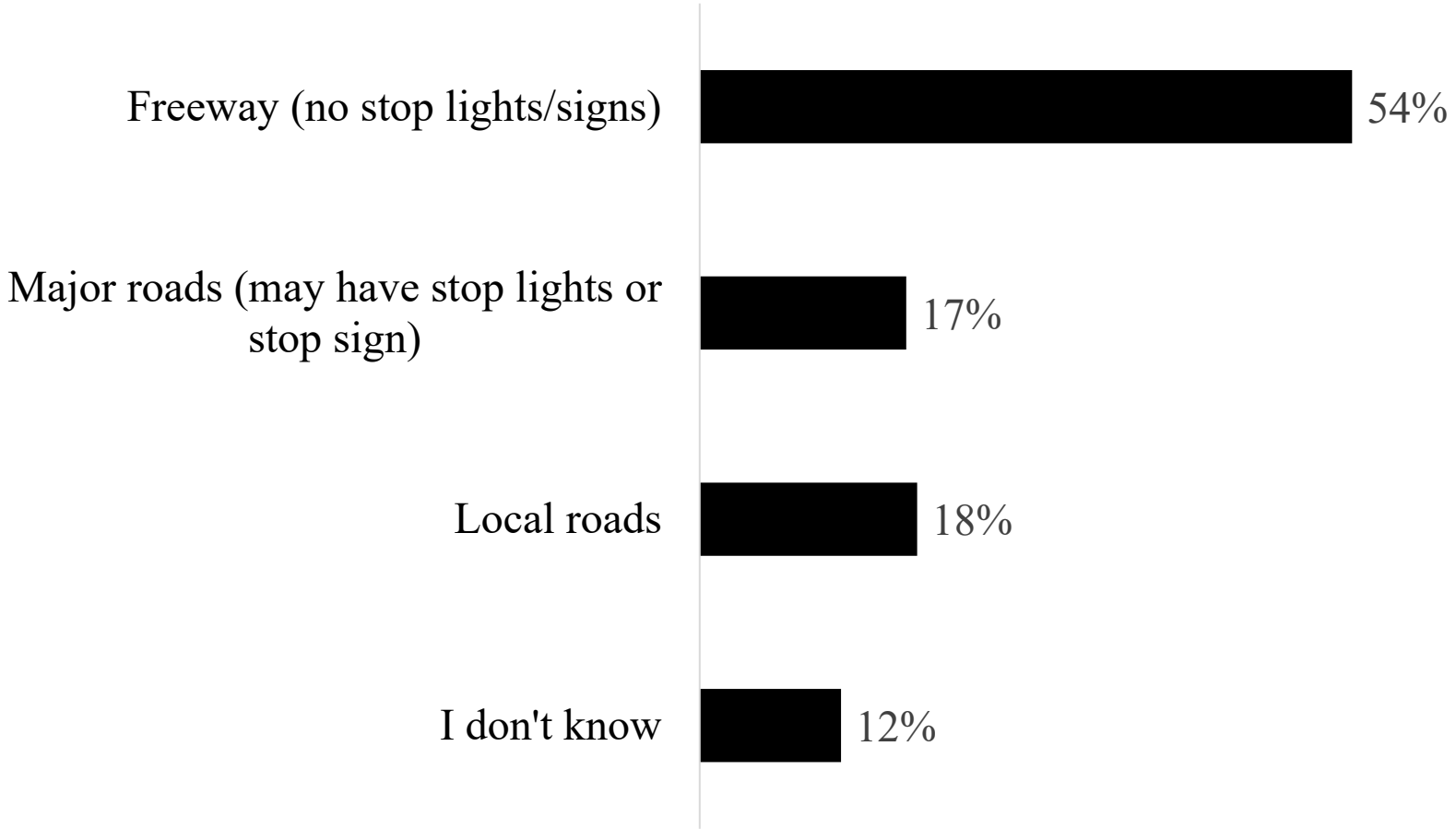
Q. If a mandatory evacuation order was issued, when would you most likely leave to your destination after the order was issued? (N=112)



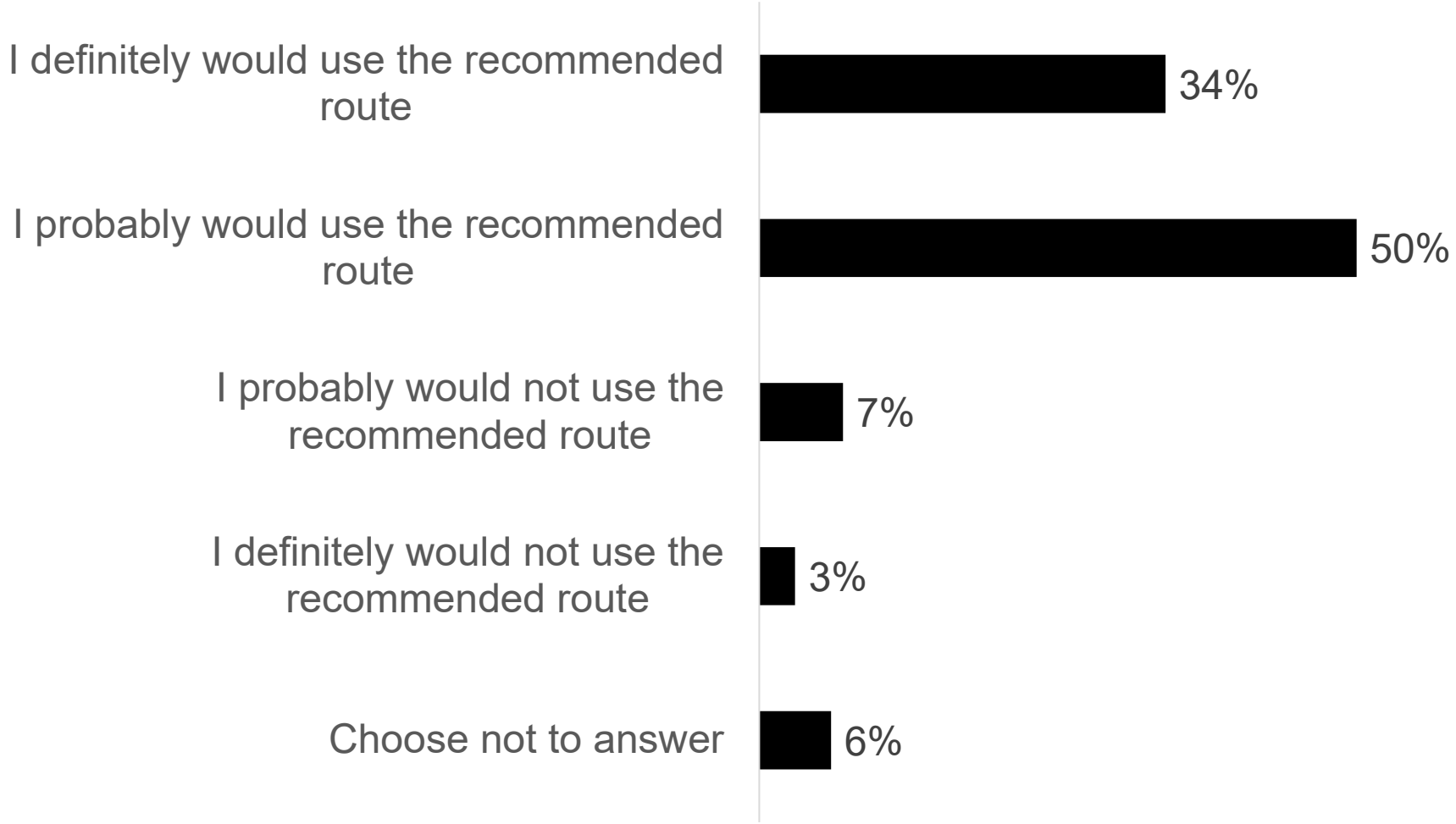
Q8. Which type of road would you mostly travel on? (N= 647)



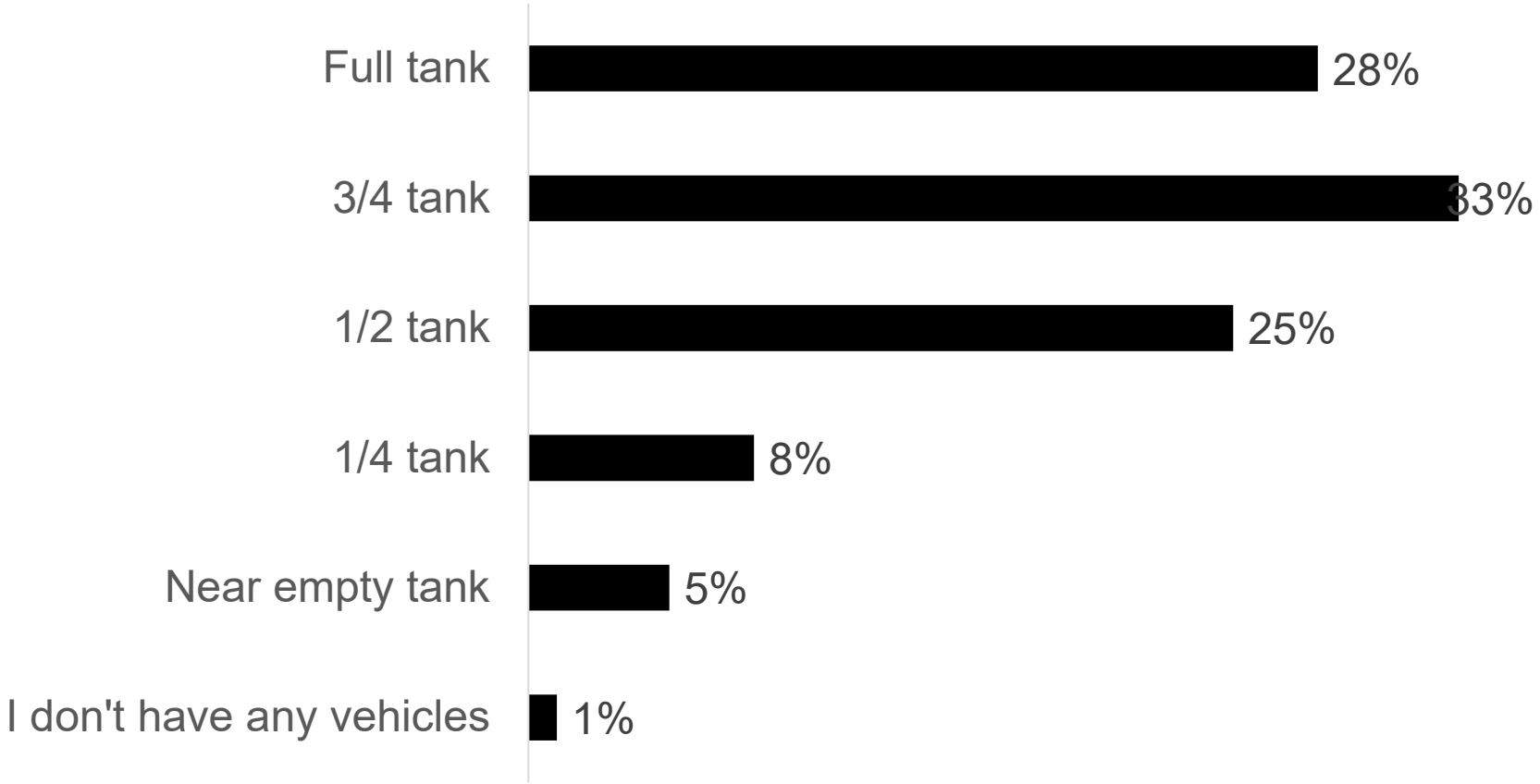
Q. Which type of road would you mostly travel on? (N=112)



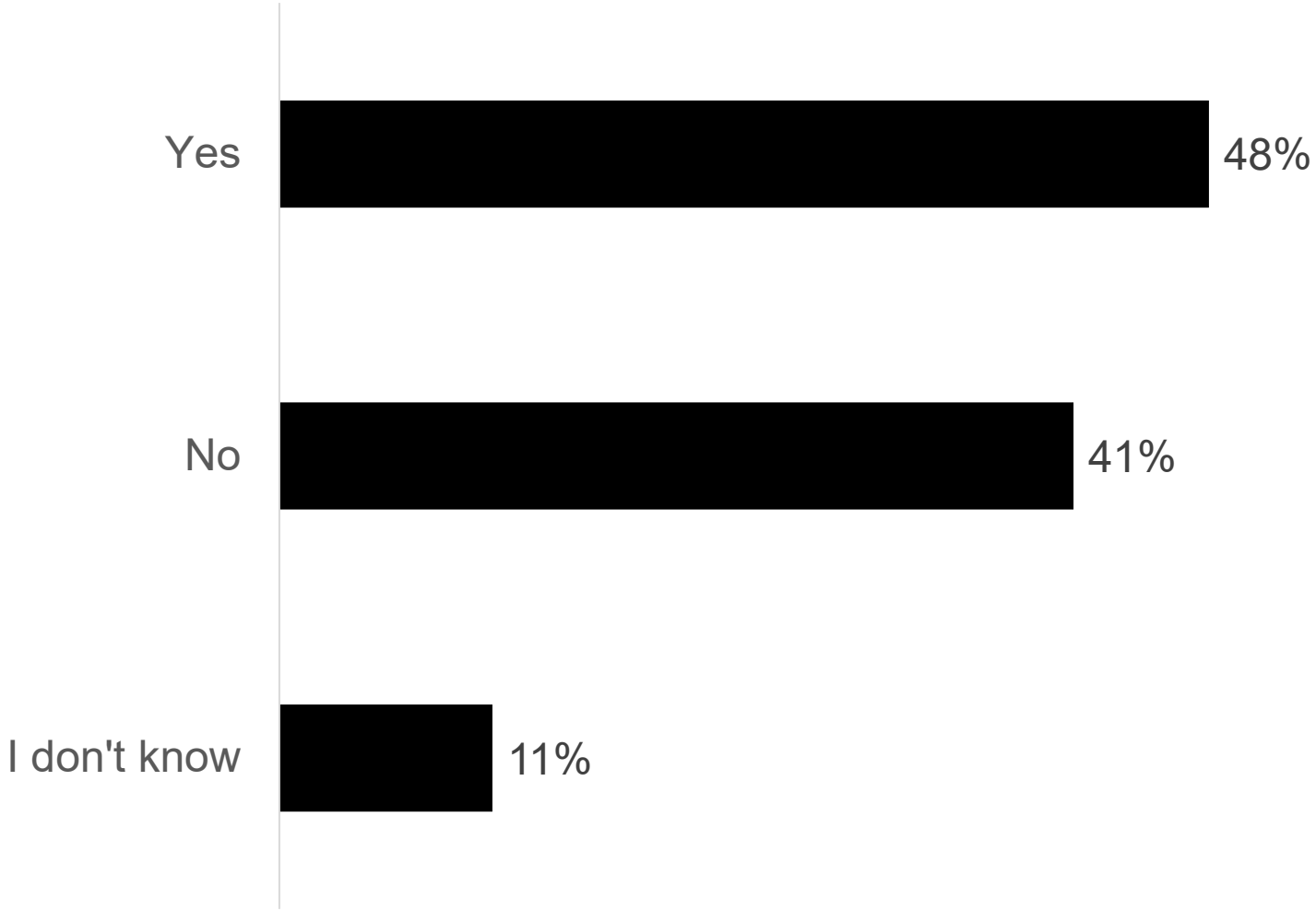
Q9. If officials recommend using a particular evacuation route, would you use that route? (N= 649)



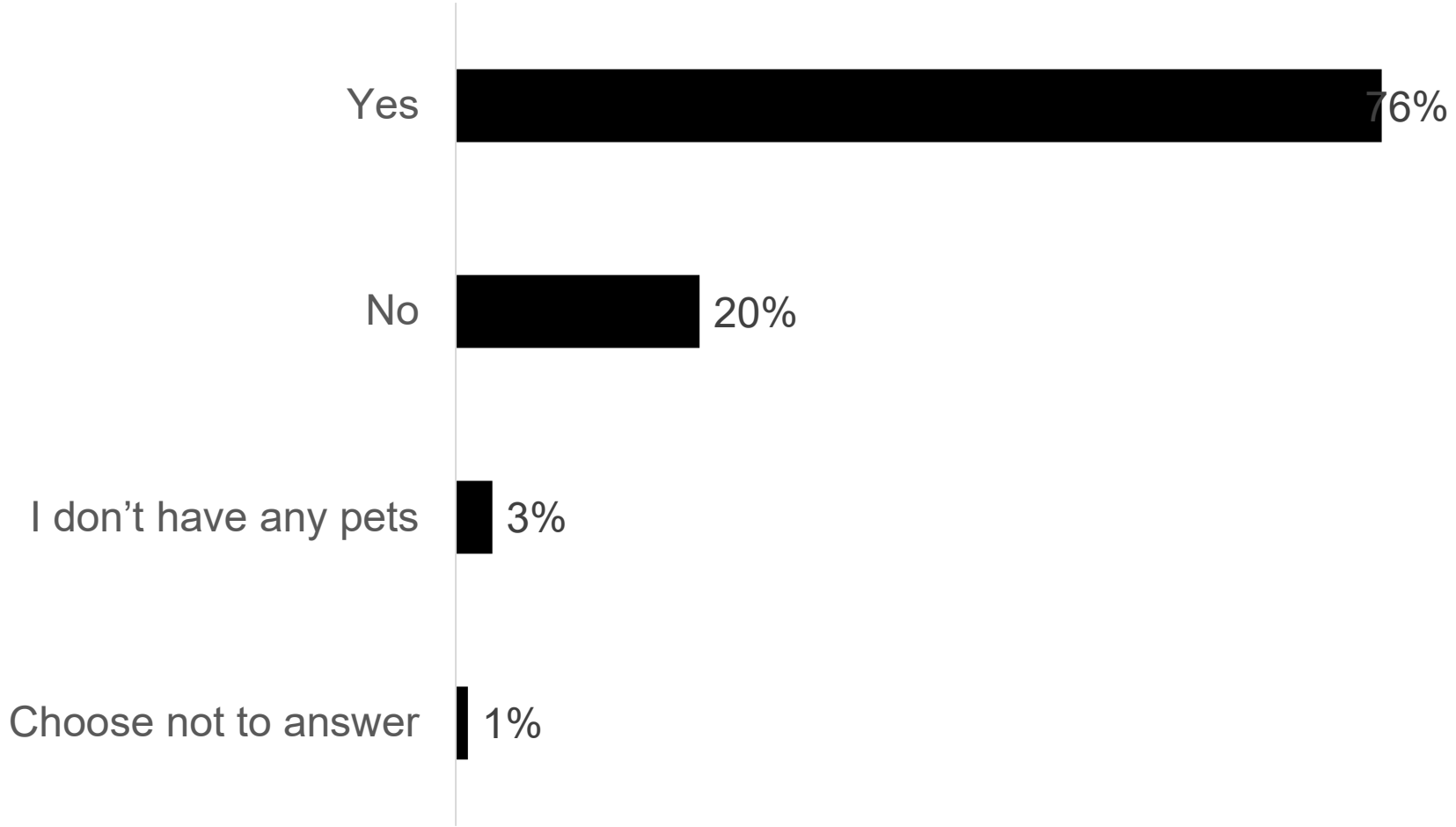
Q11. About how much fuel is in your household's primary vehicle right now? (N= 643)



Q12. Do you think this is enough fuel for you to reach the place you think you would evacuate to? (N= 643)



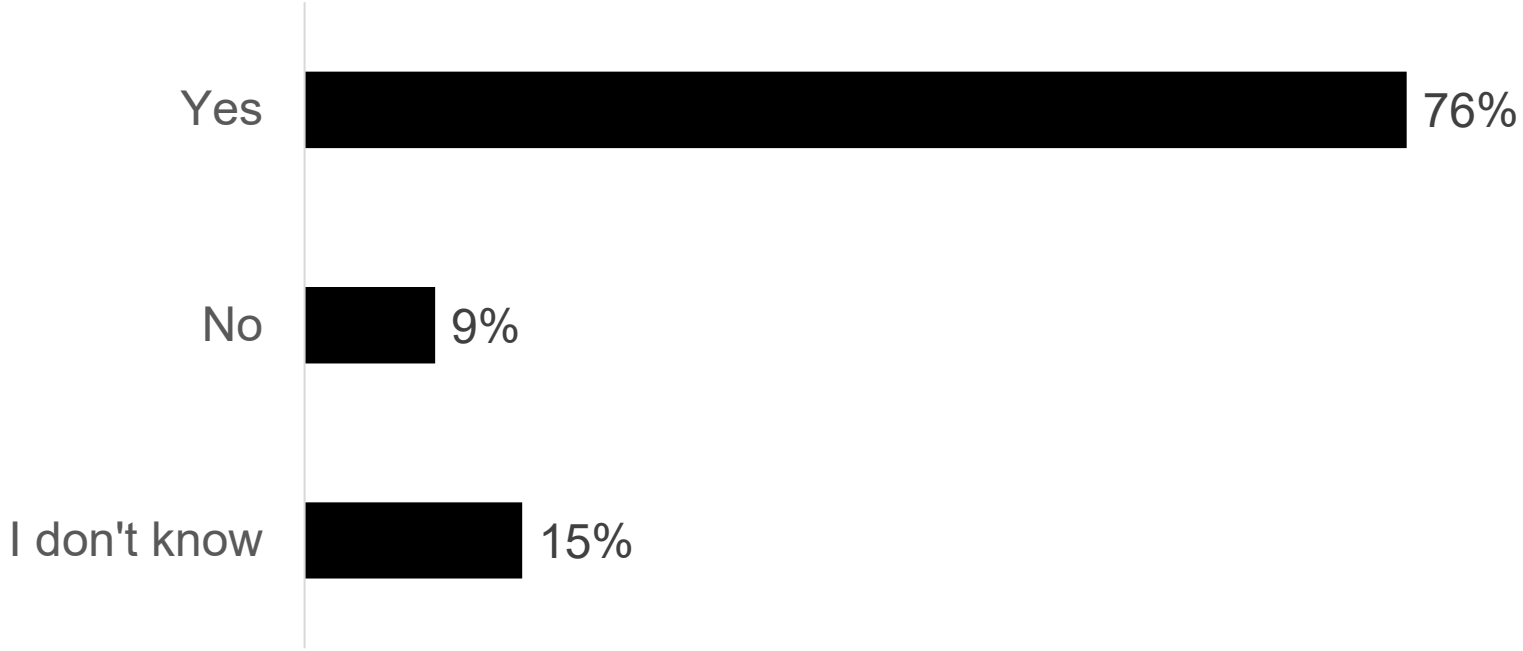
Q13. If you have any pets, will you take them with you if you evacuate? (N= 650)



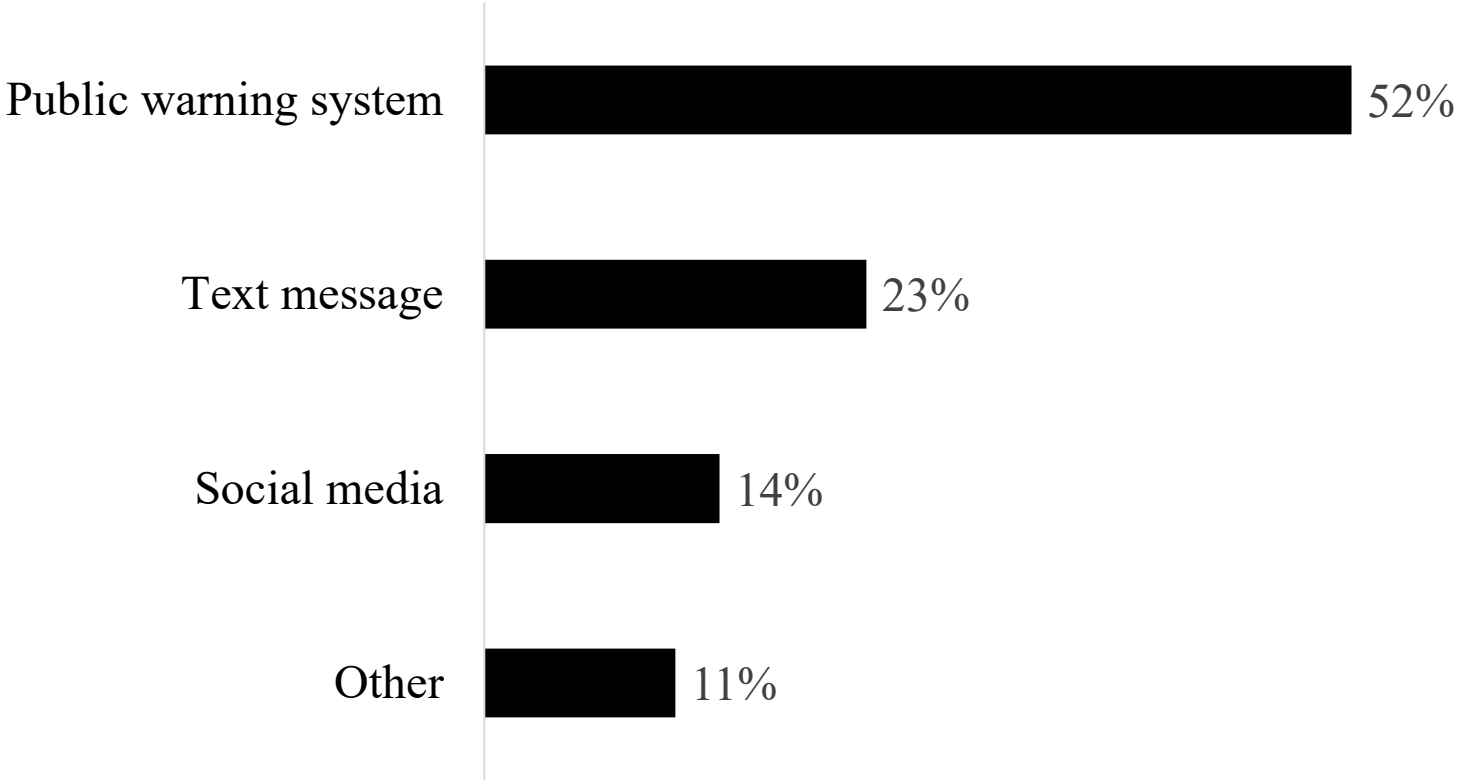
Earthquake Scenario

For the rest of the survey, we want you to imagine that a catastrophic earthquake of magnitude 8.0 has occurred in the New Madrid region. This region has experienced severe infrastructure damage with households losing access to basic utilities (power, internet, water, gas). A mandatory evacuation order has been given for your neighborhood. Please keep this scenario in mind as you answer the remaining questions.

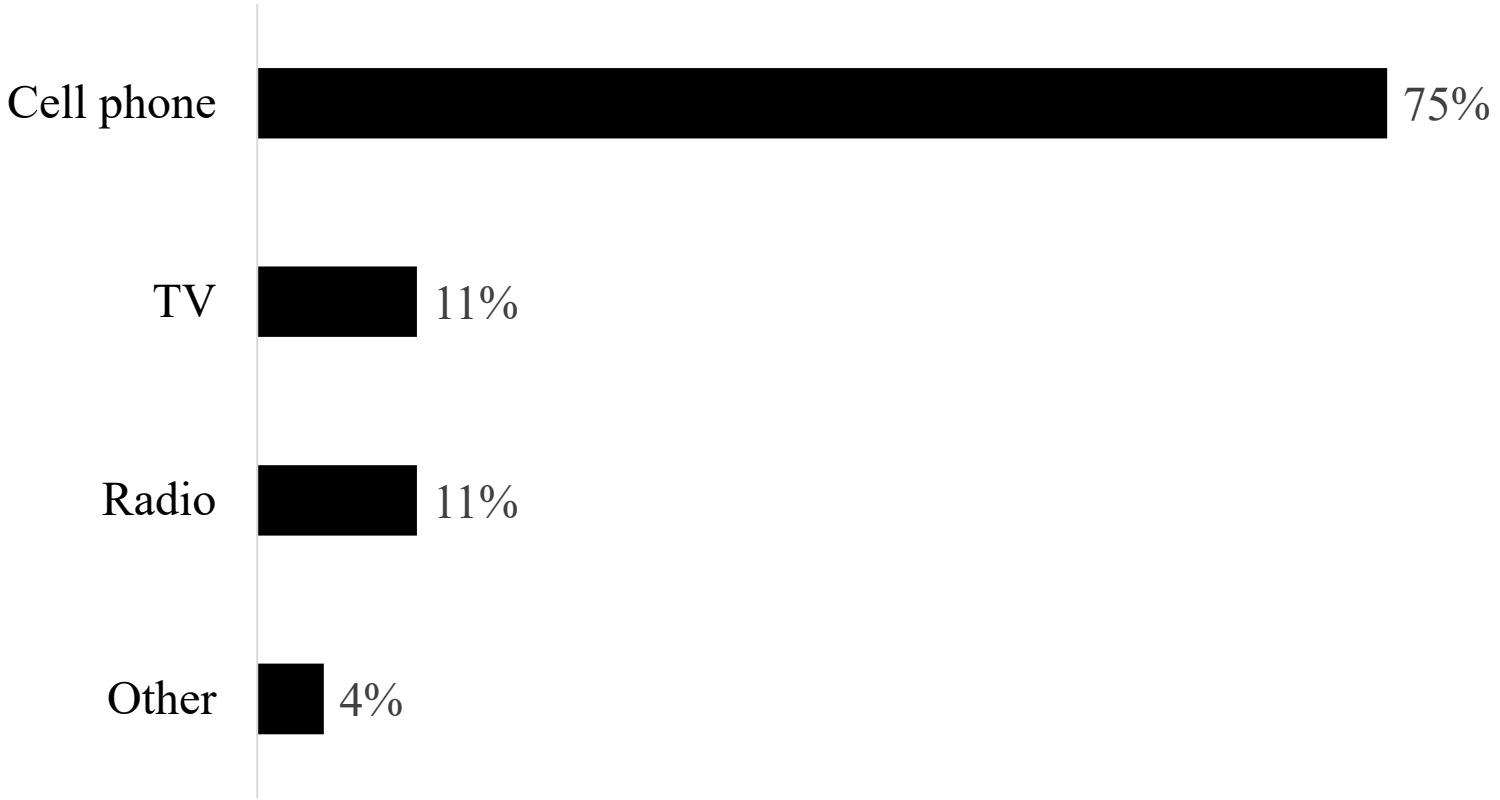
Q14. Given the scenario described above, would you evacuate? (N= 592)



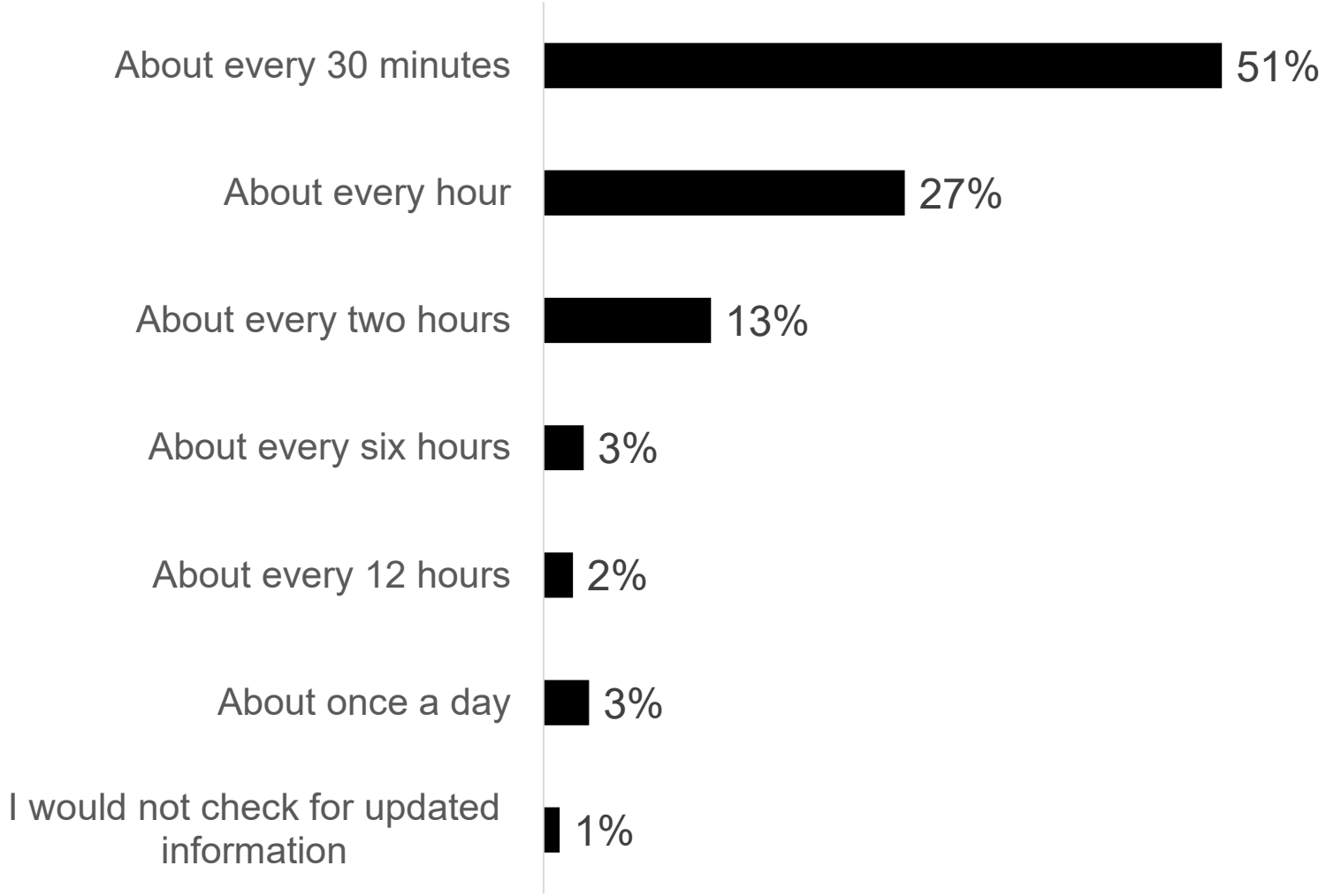
Q. From what sources do you expect to receive information related to evacuation? (N= 114)



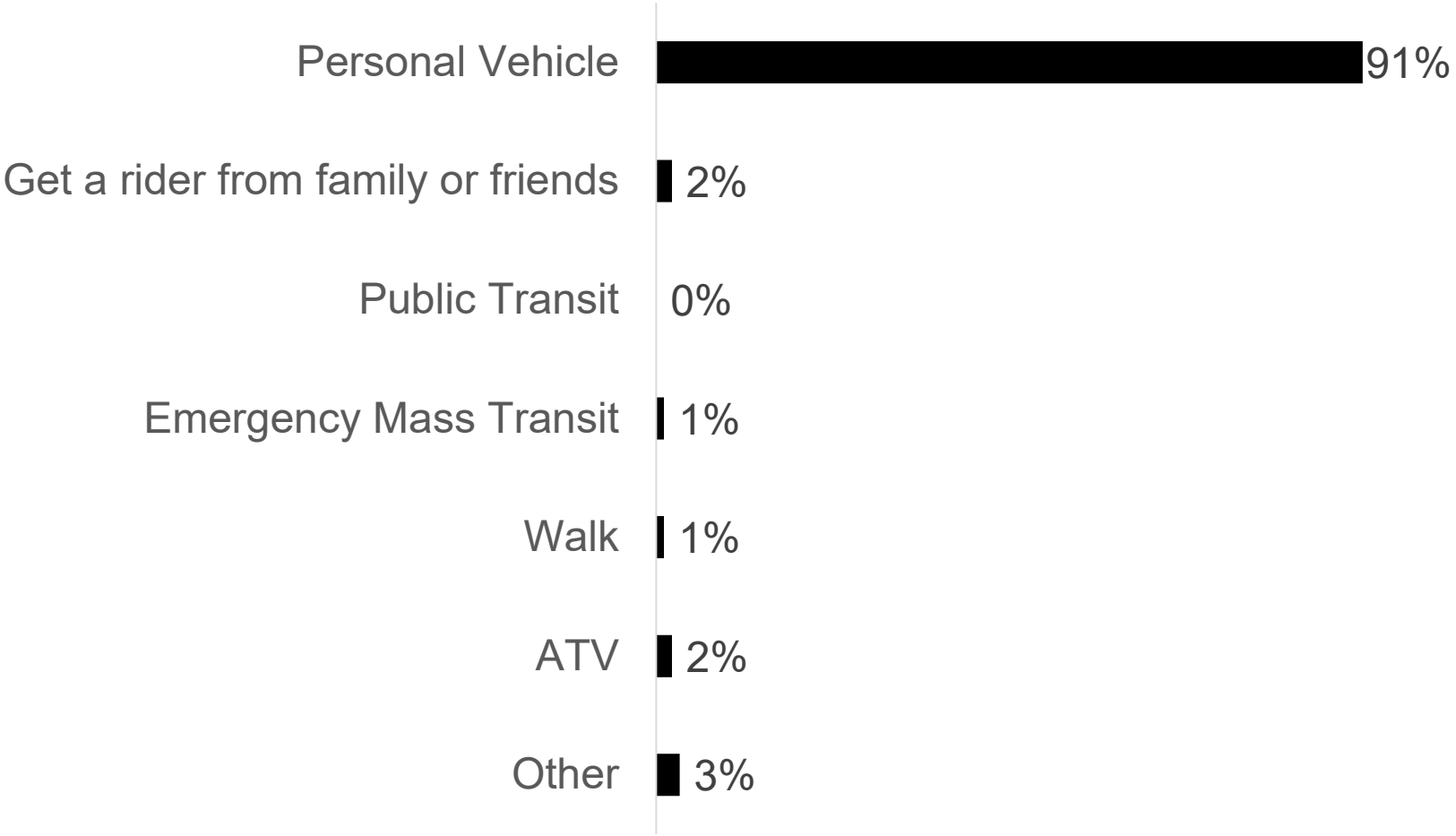
Q. From what devices do you expect to receive information related to evacuation? (N= 114)



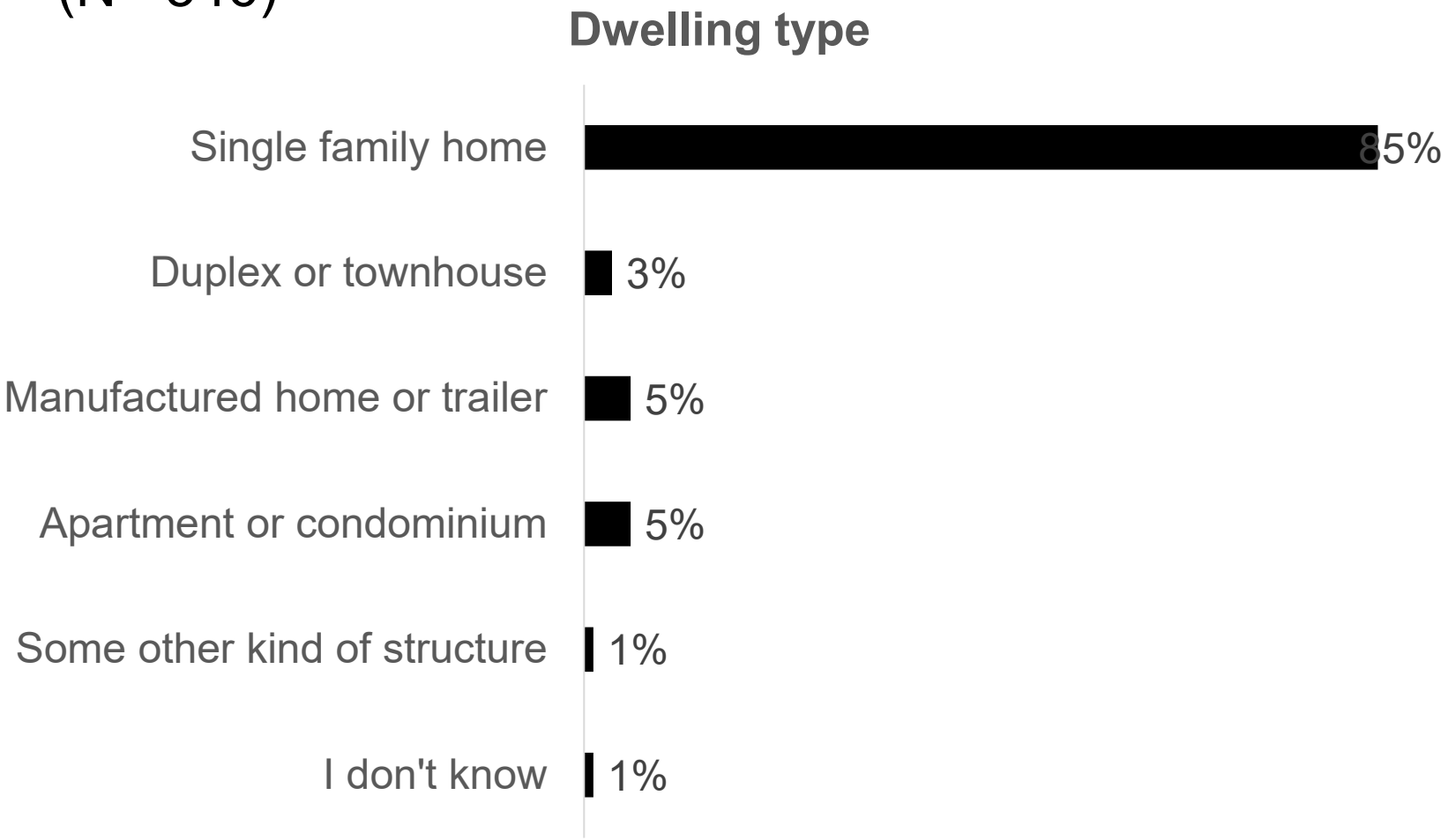
Q15. How frequently would you check for updated information on the earthquake and/or the evacuation? (N= 592)



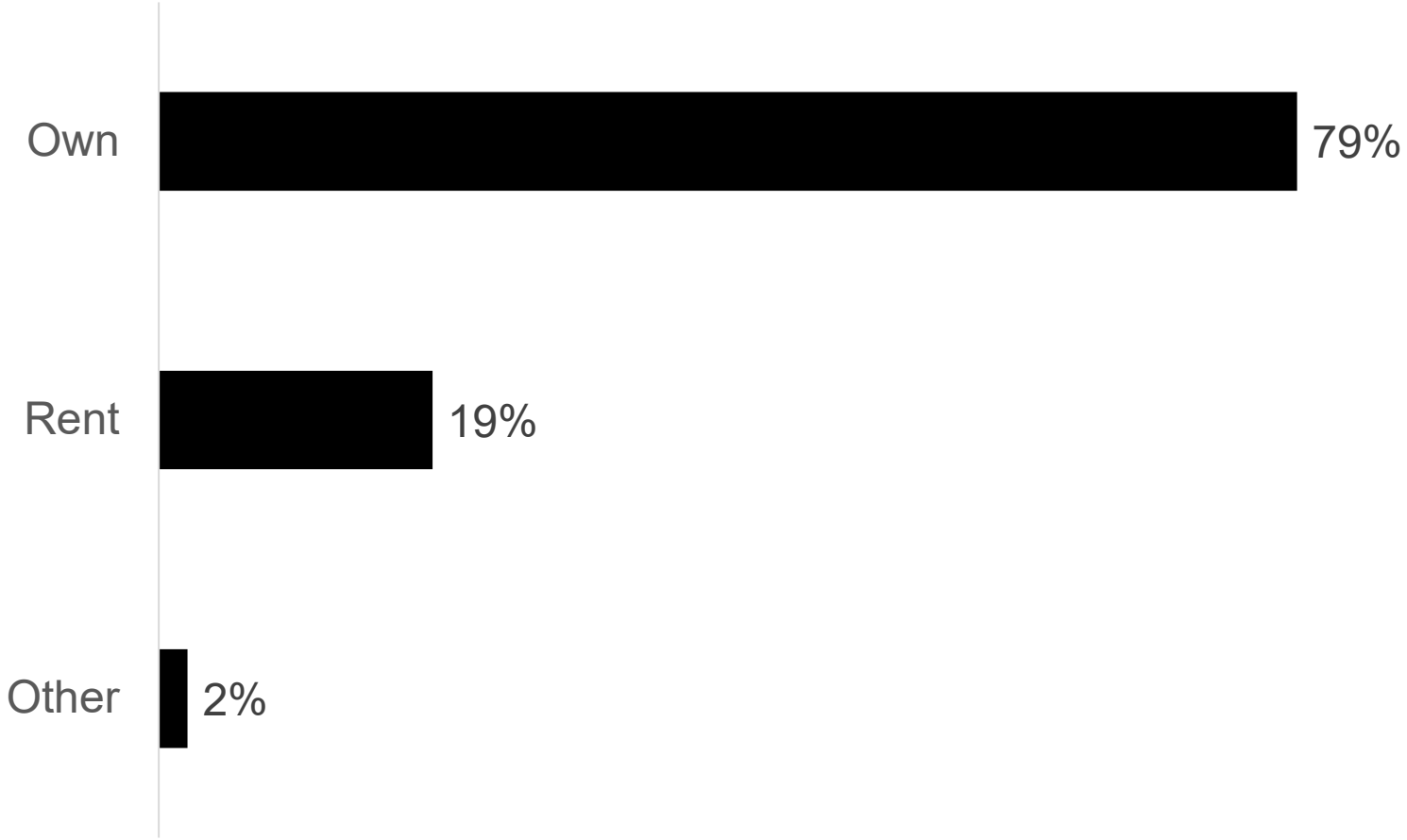
Q16. Which of the following options would you be most likely to use to evacuate? (N= 586)



Q17. Which of the following best describes your home? (N= 546)

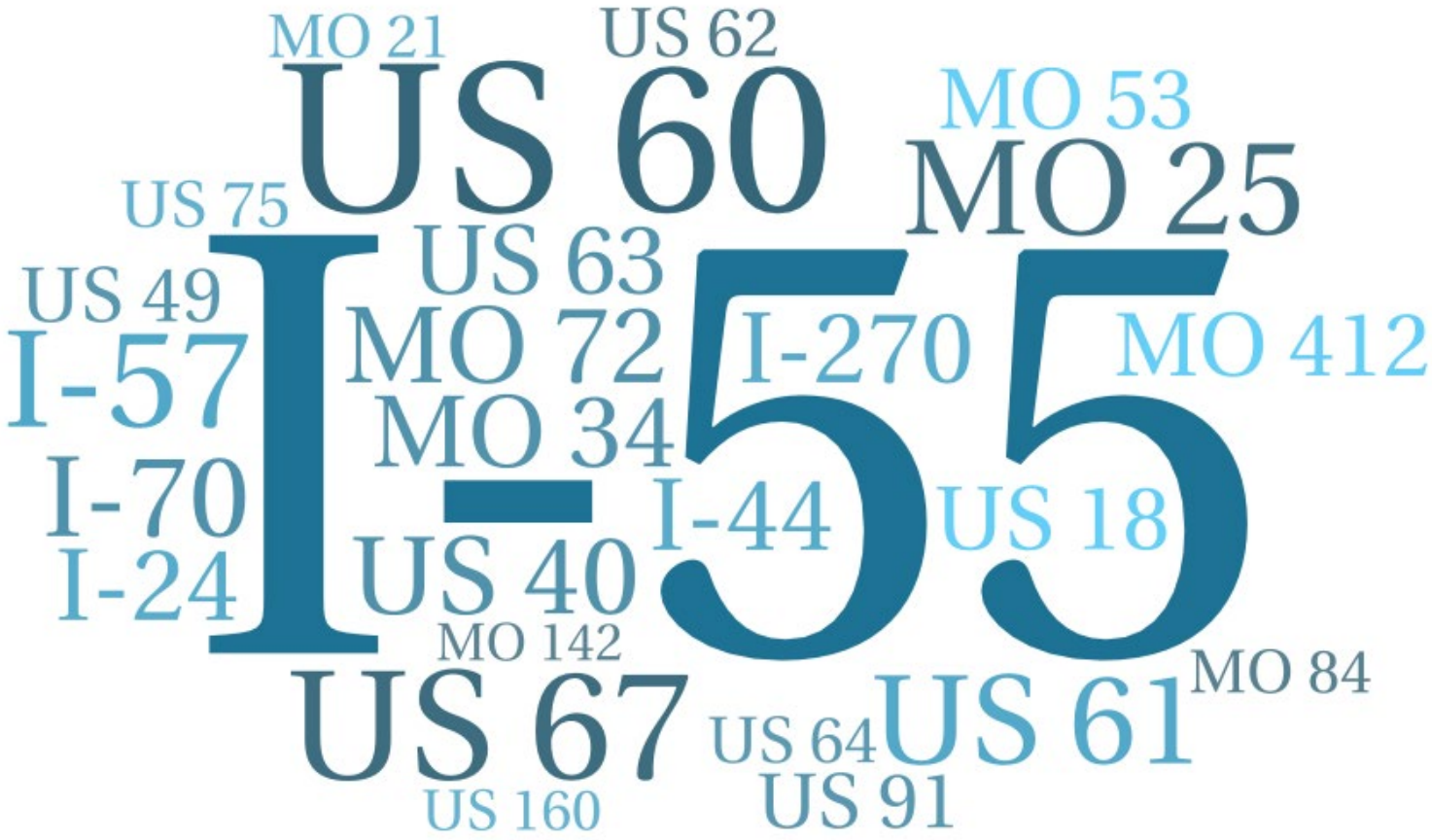


Q18. Do you (or your family) own your residence or do you rent? (N= 544)



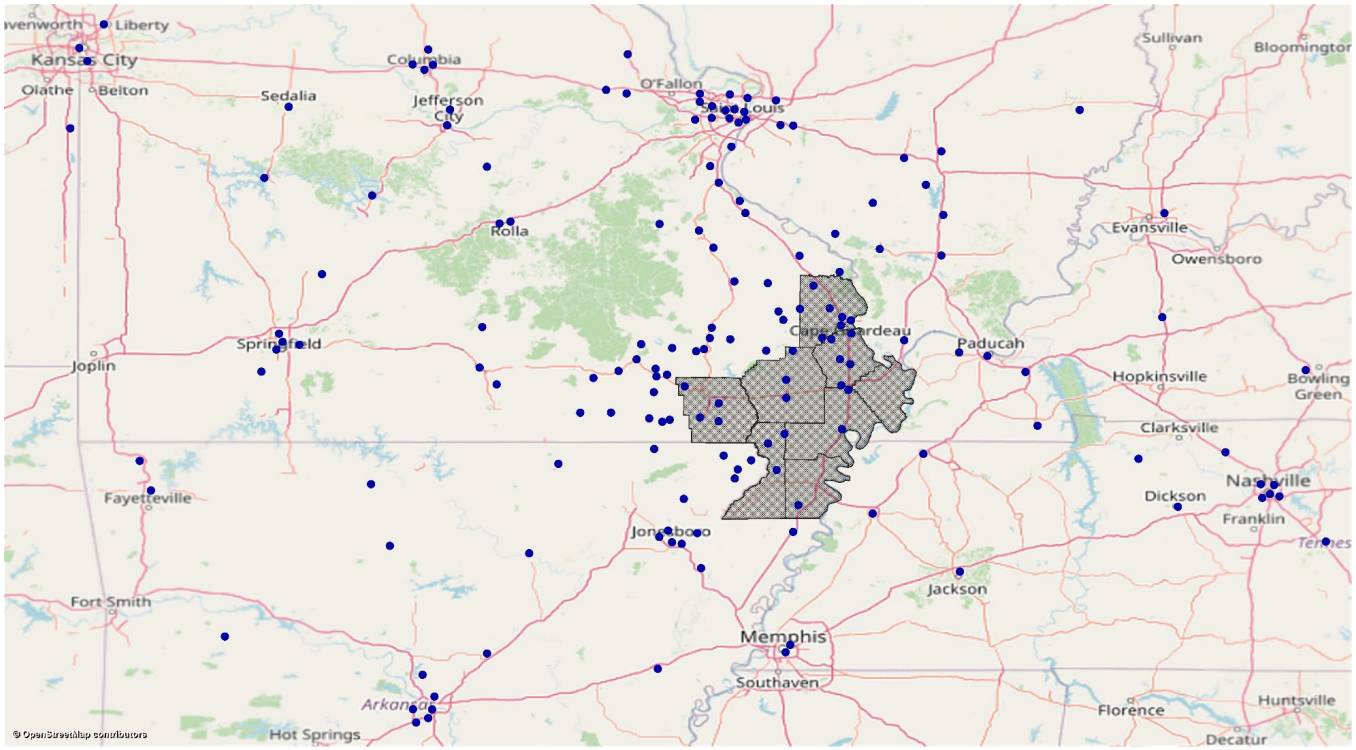
Q19. Where would you go? (N= 603)

Q20. What route would you take to get there? (N= 539)



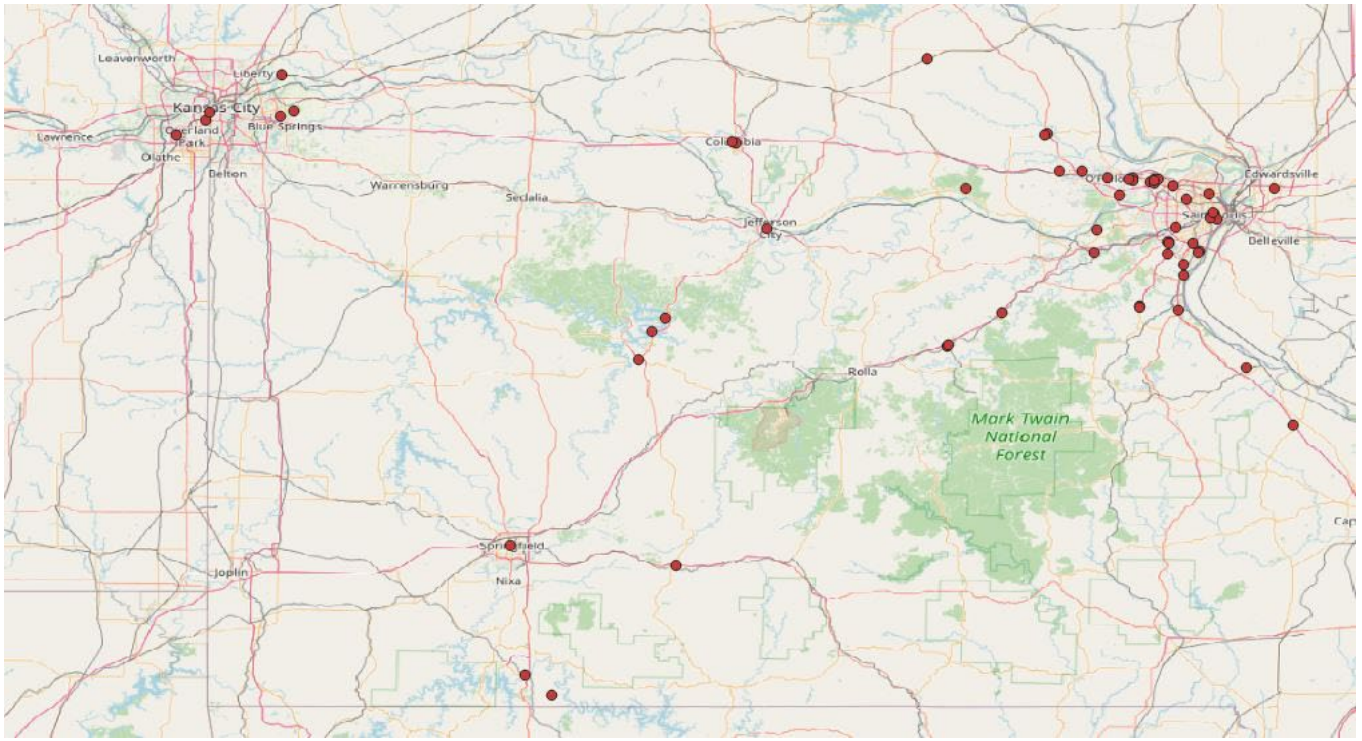
Q. What route would you take to get to your destination? (N=105)

Destination choice



Destination	St. Louis	Springfield	Arkansas	Kansas City+ Columbia+ Jefferson city	In region (within eight counties)
Percentage	27.3%	18.1%	19.7%	11.7%	23.2%

Q. Where would you go? Please enter city name (N=82)



Red dots show destinations that respondents provided

Next Steps

- Build travel demand models using survey data and other public datasets (Census, ACS, BTS, etc)
- Generate demand between origin-destination pairs and assign it in traffic simulation models
- Generate evacuation performance measures
  - Delays, clearance time, bottlenecks

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