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Nonradiological Health Consequences from Evacuation and Relocation

HPS 66th Annual Meeting
July 29, 2021

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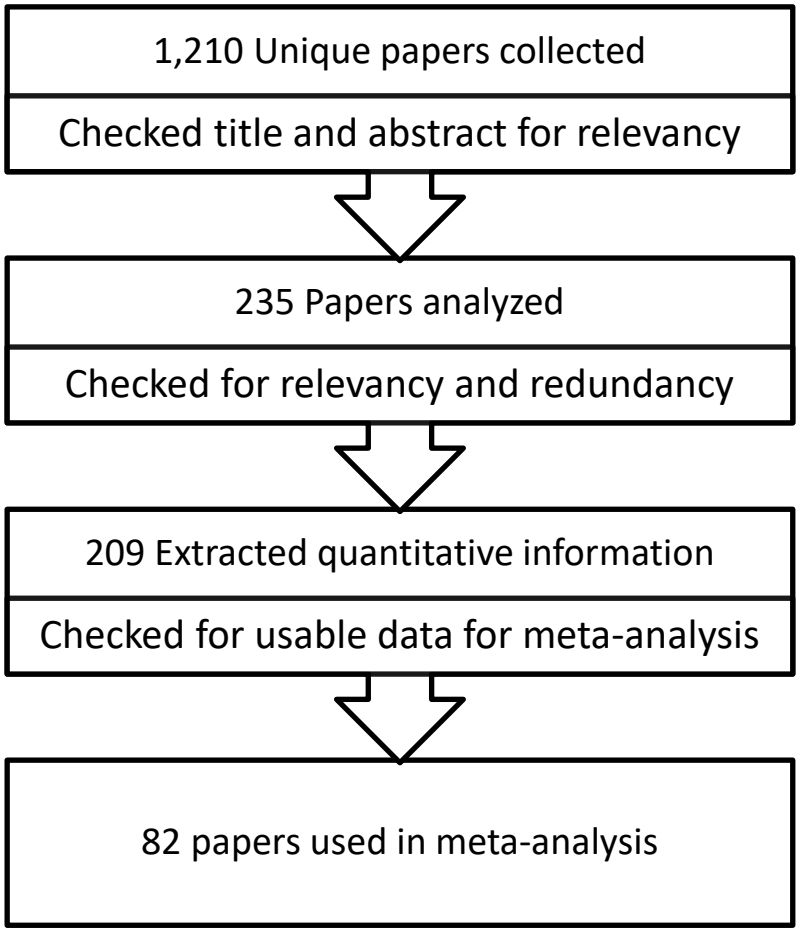
Project Background

- Evacuation and relocation are key protective actions recommended in a radiological emergency
- Despite being protective of the hazard, evacuation and relocation have inherent risks associated with them
  - The holistic risk has not been fully quantified, making it difficult for emergency managers to thoughtfully weigh the risks
- This project seeks to quantitatively and qualitatively evaluate the risks associated with evacuation and relocation

Literature Review Methodology

- Collected papers covering a multitude of events and health outcomes
- Filtered based on:
  - Relevancy
  - Redundancy
  - Reliability
  - Newcastle-Ottawa Scale
- Excluded from meta-analysis if populations were conflated or ambiguous



Human Health Effects

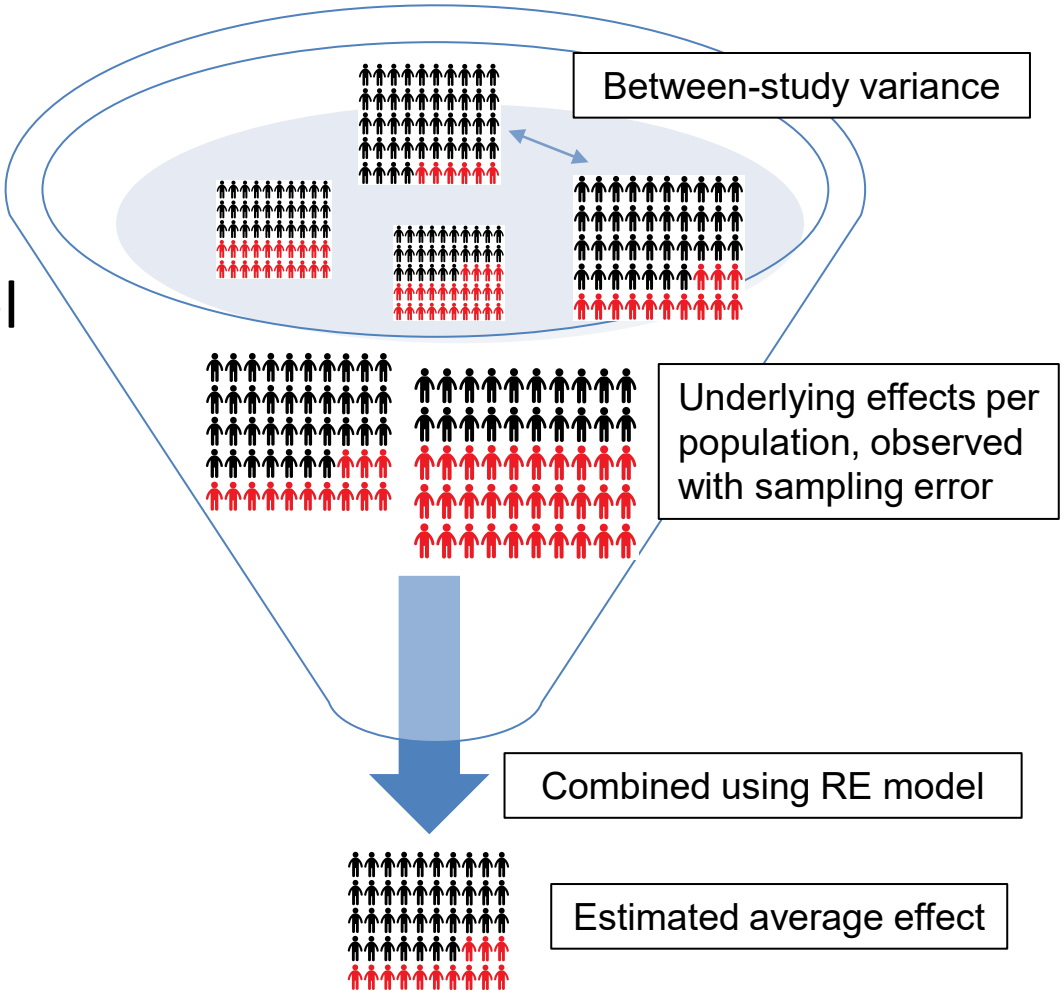
- 14 health effects among 9 emergency event types were identified across all studies in the review

Broad effects	# of papers in meta-analysis
General Health Effects	18
Healthcare Accessibility	5
Other miscellaneous effects	8
Psychological Distress	23
Substance Abuse	11

Specific effects	# of papers in meta-analysis
Anxiety	10
Depression	17
PTSD	32
Diabetes	10
Heart Disease	12
Mortality	8
Weight Problems	6
Respiratory	5
Sleep Problems	4

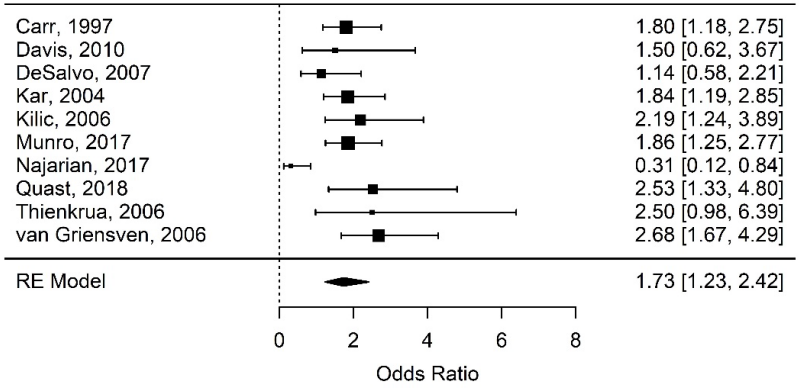
Meta-analysis of Effect Sizes

- Effect size
  - Population proportion or odds ratio
- Random Effects Model
  - RE models are used to combine individual study effect sizes into an average effect size
  - Accounts for differences between studies with different population demographics and emergency event type



Meta-analysis of Effect Sizes

- Analysis estimated both **the proportion and the odds** that individuals may experience a health condition if displaced, compared to the proportion/odds if non-displaced, following an emergency event
  - Estimates are a weighted average of the proportion or odds ratio
  - Allows for an examination of the association between negative health outcomes (e.g., experiencing PTSD) and displacement
- Visualized using a forest plot
  - Shows individual effect sizes
  - Individual-level variance of each study
  - Final pooled estimate and 95% confidence interval

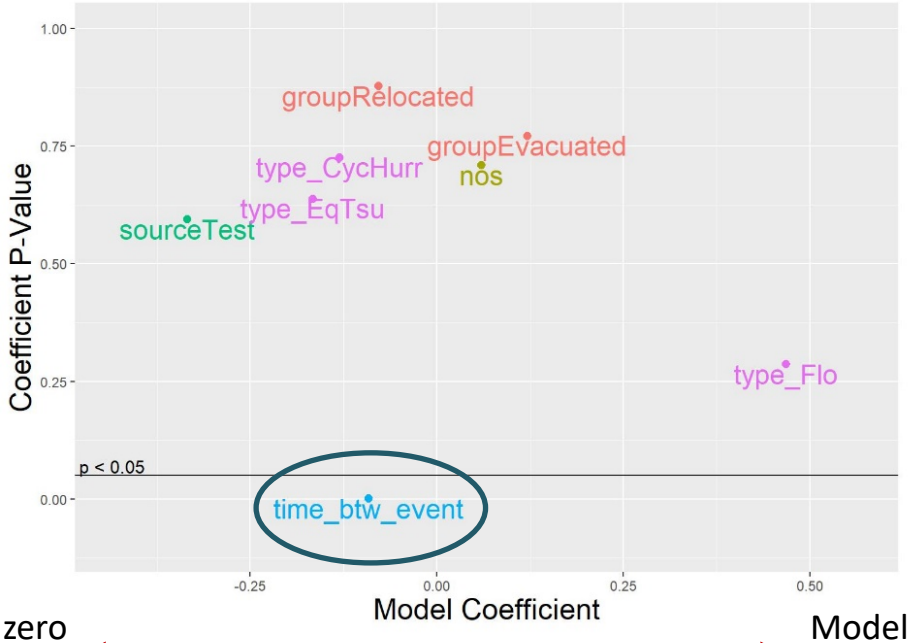


Example: Comparative effect size for PTSD in evacuated or relocated groups following an emergency, $\widehat{OR} = 1.73\ (1.23, 2.42)$

Meta-Regression of Study Characteristics

- The study characteristics were evaluated in individual models and results were aggregated across the health outcome to compare model coefficients and *p*-values

P-value less than p=0.05 indicates "statistical significance", or strong evidence that the model coefficient is different from zero



Model coefficients less than zero indicate a negative association with effect size

Model coefficients greater than zero indicate a positive relationship with effect size

Interpretation of Odds Ratios

$\widehat{OR} > 1$

For displaced populations, there is a greater likelihood of experiencing a negative health outcome

$\widehat{OR} = 1$

Displacement following an emergency has no statistical association with an increased likelihood of experiencing a particular health outcome

$\widehat{OR} < 1$

For non-displaced populations, there is a greater likelihood of experiencing a negative health outcome

Summary of Odds Ratio Findings

- Displaced individuals more likely to suffer from negative health effects
- "All Health Effects" is estimated at OR=1.49
  - Study aggregate across all disaster and health effect types
  - Evacuation and relocation are related to a greater likelihood of experiencing a negative health outcome

Outcome	Odds Ratio	Confidence Interval	Significant (95% level)
Anxiety	1.29	(0.84, 1.97)	
Depression	2.50	(1.87, 3.35)	Yes
Diabetes	1.19	(1.08, 1.32)	Yes
General Health Effects	1.94	(1.14, 3.30)	Yes
Healthcare Accessibility Problems	2.04	(0.81, 5.18)	
Heart Disease	1.07	(0.88, 1.31)	
Mortality	1.76	(1.49, 2.09)	Yes
PTSD	1.73	(1.23, 2.42)	Yes
Psychological Distress	1.68	(1.19, 2.38)	Yes
Respiratory Problems	1.48	(0.96, 2.30)	
Sleep Problems	1.63	(1.53, 1.74)	Yes
Substance Abuse	1.11	(0.97, 1.27)	
Weight Problems	1.43	(1.17, 1.75)	Yes
Other Effects	2.86	(1.81, 4.52)	Yes
All Health Effects	**1.49**	**(1.24, 1.79)**	**Yes**

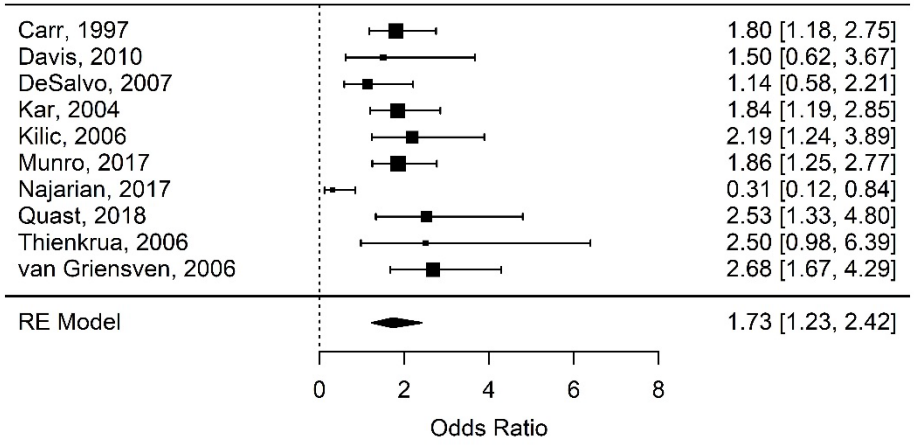
PTSD Meta-analysis

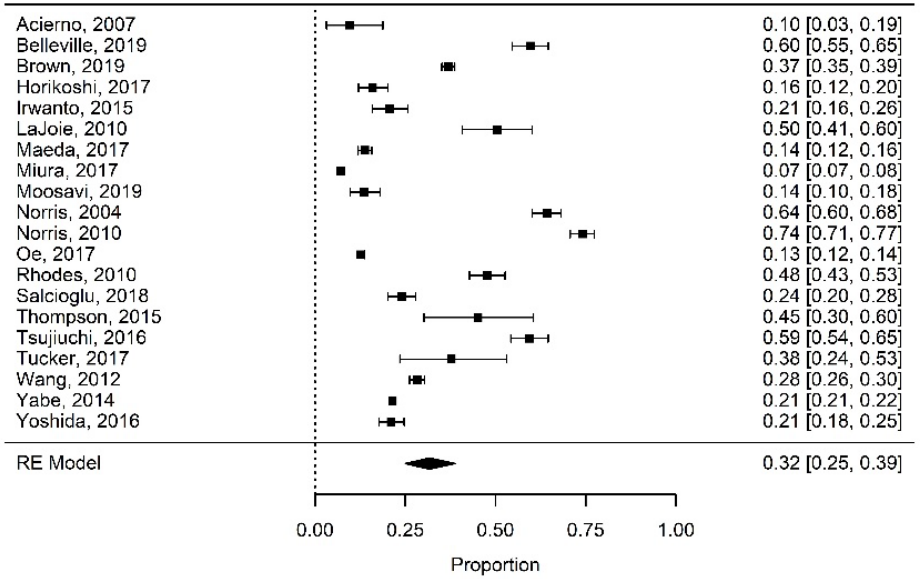
Displaced individuals were more likely to experience PTSD, with an overall average odds ratio of 1.73

Reflected in a large disparity in the overall prevalence of PTSD in the displaced (right) and nondisplaced populations (p=0.15, not pictured)

However, PTSD prevalence is high in both groups

- PTSD is nearly inevitable among a population following man-made or natural emergencies whether or not there was an evacuation event (Neria, 2008)





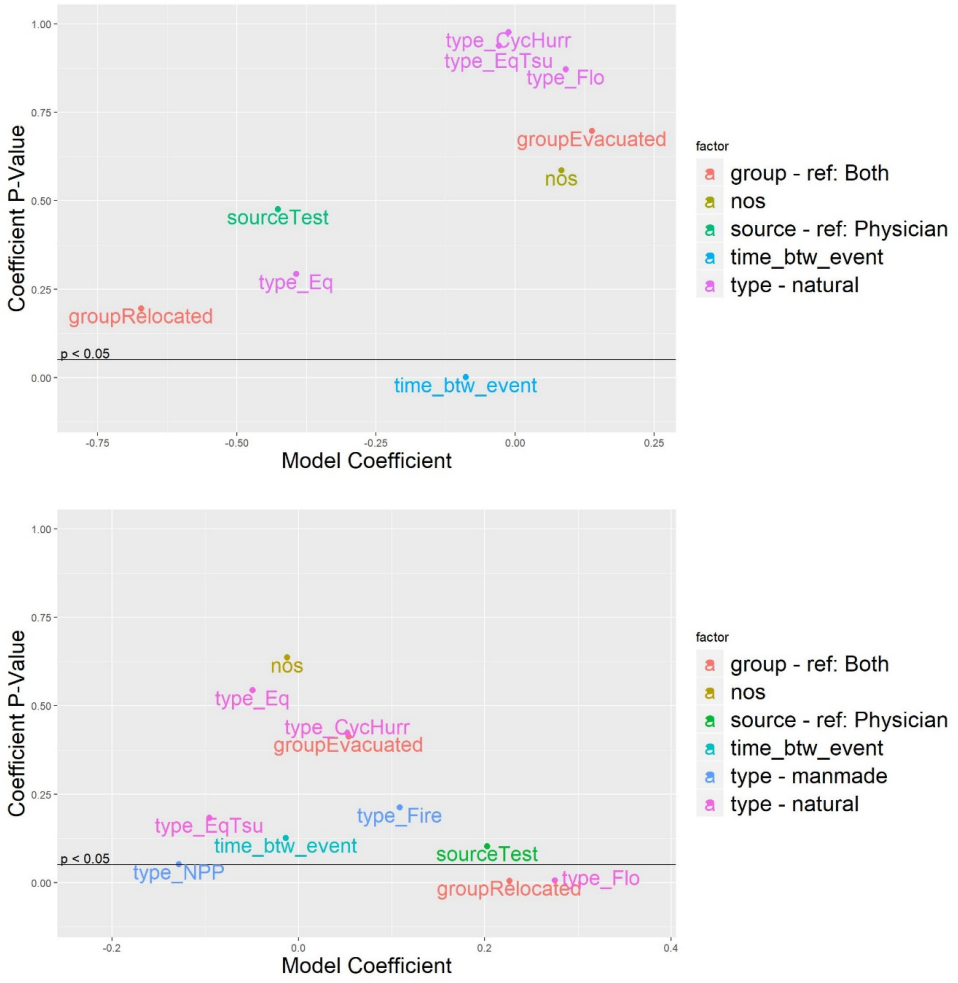
PTSD Meta-regression

Only one statistically significant variable was identified in the odds ratio analysis

- Time between the emergency event and the data collection

Displaced population only—

- Relocation and flood events both associated with higher prevalence of PTSD
- Nuclear power plant accidents were not significant at the p<0.05 level but were associated with lower prevalence of PTSD



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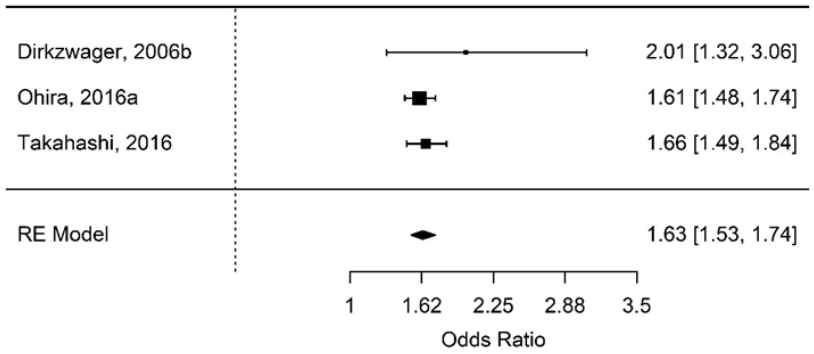
Sleep Problems

Displaced populations reported more sleep problems

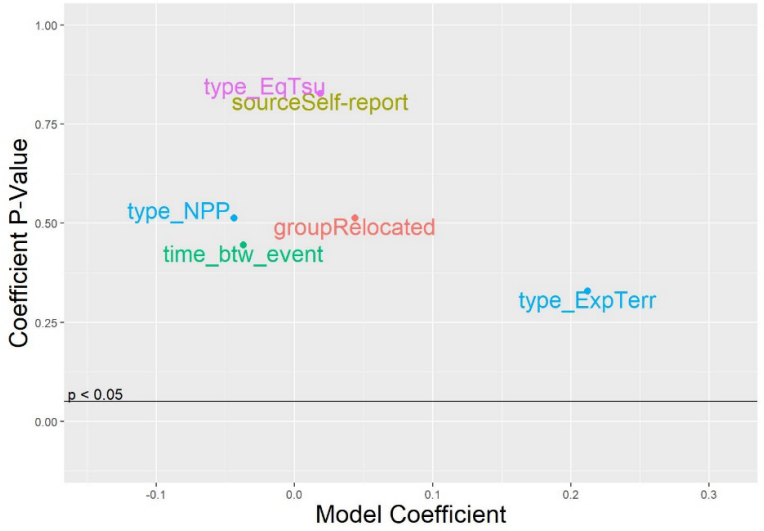
- Likely a causal relationship between displacement and sleep problems as evacuees cope with the stress reactions and are anxious to return home



No individual variables were significantly associated with observed sleep problems

- Several at-risk groups or other potential factors that could be driving sleep problems
- Children between 4 and 12 had the largest increase in sleep problems

Analysis of sleep problems difficult because people cannot reliably report the quality of their sleep



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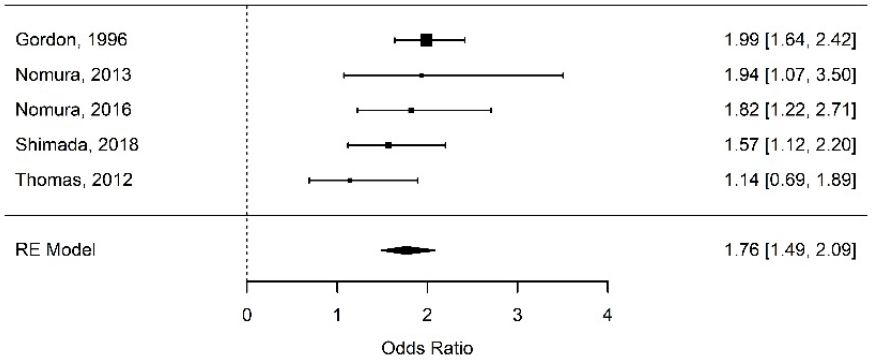
Mortality Results

Displaced populations suffered higher mortality, particularly in the first 60-90 days after displacement

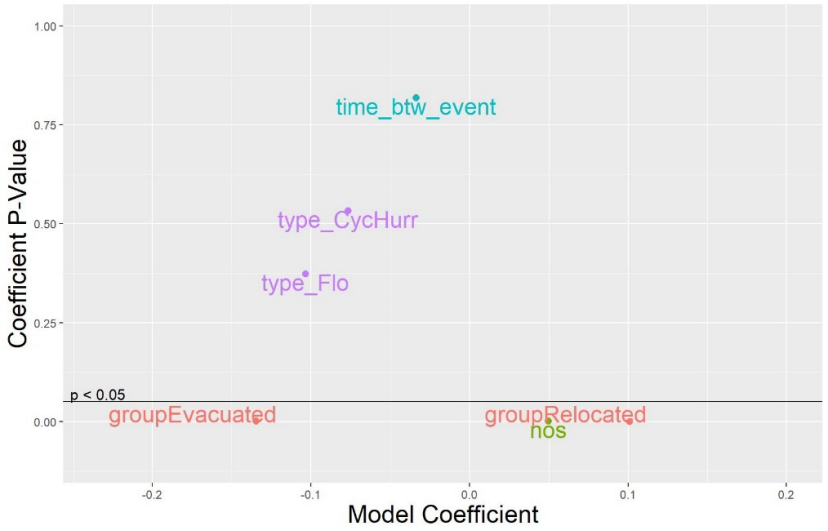
- Data includes deaths during evacuation of hospitals, elderly care or nursing facilities, and at admittees at a hospital



Meta-regression of the <u>odds ratio</u> effect size found no significant factors associated with mortality

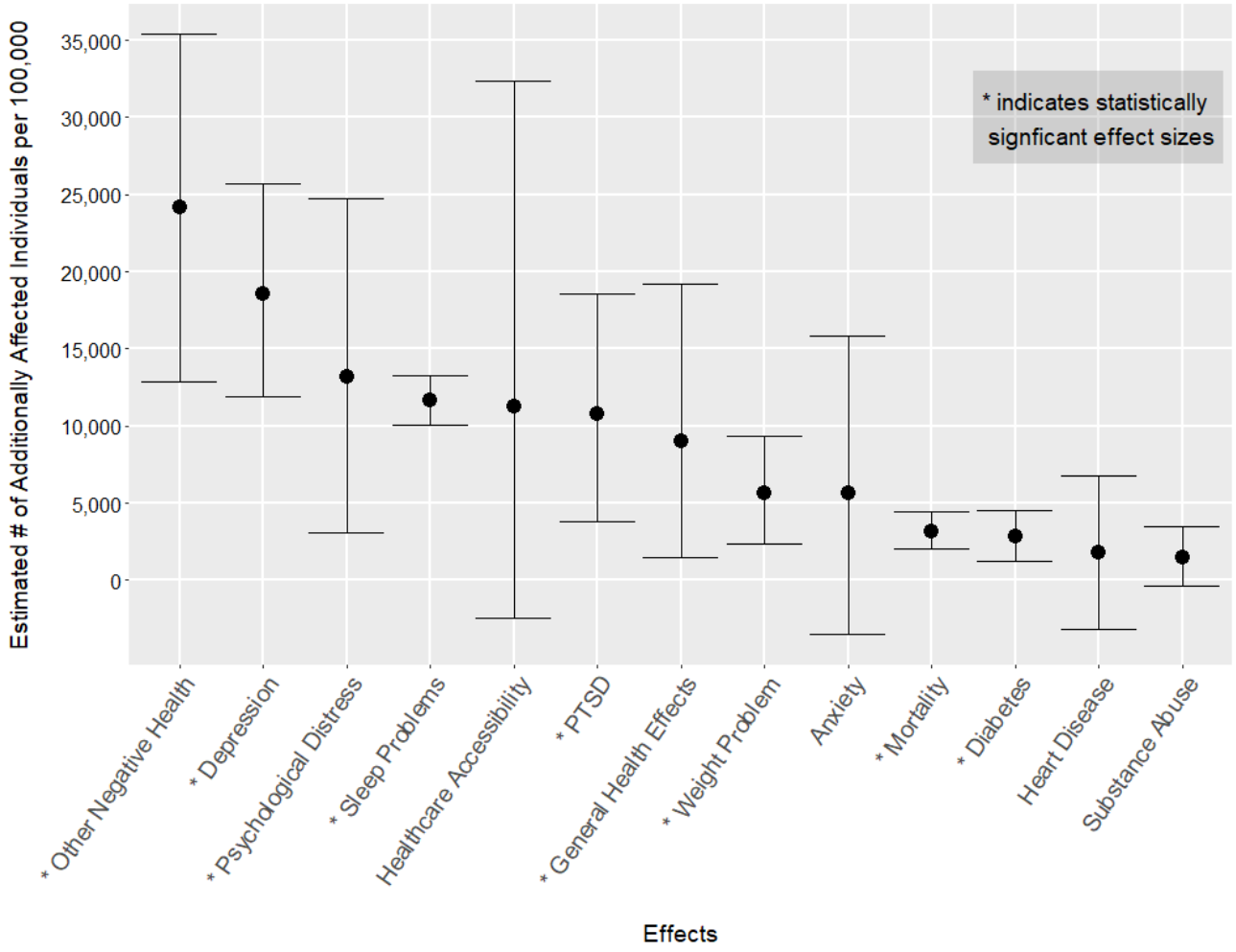
Meta-regression of the <u>prevalence</u> effect size:

- Evacuation score associated with slightly lower mortality
- Relocation associated with slightly higher mortality



* Meta-regression on the prevalence of mortality

Analysis of Estimated Magnitude of Effect



Major Conclusions

- Data demonstrates a clear relationship between evacuation/relocation and an increase in expected deleterious health effects
  - Both physical and behavioral/psychosocial
  - Correlated, but causation has not been established for all effects
- Nearly 25,000 additional people per 100,000 displaced suffer from 'other health effects'
  - Disruption of social support networks, increase in domestic abuse, memory problems in children, etc.
- Evacuation and relocation results in substantial and statistically significant increases in PTSD, depression, psychological distress, sleep problems, and mortality.
  - All health effects showed an increase among displaced populations, and most were statistically significant

Application of Findings

- Balance of the risks in protective action decision-making
  - EPA PAGs (1-5 rem) are based primarily on a hypothetical stochastic risk, that may or may not occur at some distant time in the future
  - According to radiation safety experts, radiation exposure between 5-10 rem usually results in little to no harmful health effects
  - By contrast, a noticeable increase in negative health effects are directly observed in displaced populations within a short time period
- Clearest application is recognizing that there are significant health effects from prolonged displacement
  - Should evacuation/relocation decisions seek to minimize the number of people displaced?
  - How do we avoid prolonged evacuation?
  - Is sheltering-in-place a viable alternative to evacuation?
  - What are the information needs of decision-makers and the public?

Acknowledgement

NUREG/CR-7285 Nonradiological Health Consequences from Evacuation and Relocation

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Questions

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