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Nonradiological Health Consequences from Evacuation and Relocation

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ABSTRACT

Evacuation and relocation are protective actions that can be implemented to prevent or reduce exposure to a hazard following emergency events, but they are not without their own risks. Previous research has identified these risks, but the aggregate of the risk has not been quantified. This study includes a meta-analysis of 14 health effects experienced by evacuees and relocated populations. Effects studied include anxiety, heart disease, and mortality, among others. Following a literature review of more than 1,200 papers, the authors selected 82 papers for a meta-analysis. The likelihood of an effect in a population was estimated using odds ratios and the prevalence of health effects in displaced and nondisplaced populations across various hazards. A meta-regression was performed to identify which event factors contributed to unusually high or low prevalence of health effects among displaced or nondisplaced populations. The meta-analysis showed an association between displacement and an increase in all the negative health effects studied. Additionally, a higher prevalence among displaced populations was statistically significant for nine health effects. These findings confirm that evacuation and relocation have associated quantifiable long-term risks as a result of the prolonged displacement. This information is an important factor in risk-informed protective actions for radiological emergencies.

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EXECUTIVE SUMMARY

This report provides insight into the nonradiological health consequences associated with evacuation and relocation. The study includes a review of the scientific literature and a meta-analysis of the data to examine negative health effects in evacuated and relocated populations in response to various emergencies, including nuclear power plant accidents.

The literature search examined more than 1,200 papers and identified 209 with quantitative information on health effects relevant to the meta-analysis. The authors reviewed articles on health effects of interest among evacuated or relocated populations and scored each article for quality based on the Newcastle-Ottawa Scale. Relevant articles were selected for further analysis by removing articles with redundant data and excluding articles that did not clearly distinguish between displaced and nondisplaced populations. This review identified 14 health effects for analysis:

- anxiety
- depression
- diabetes
- healthcare accessibility problems
- heart disease
- mortality
- weight problems, including both increases and decreases
- psychological distress
- posttraumatic stress disorder (PTSD)
- sleep problems
- respiratory problems
- substance abuse
- general health effects, such as changes in blood pressure
- other miscellaneous effects, such as loss of social support networks

Included studies were sorted into three groups depending on the study population. The first group included papers that only examined displaced populations. The second group comprised papers that included both displaced and nondisplaced populations and reported the health effects in each group separately. The third group, which was the smallest of the three, contained papers that only examined populations that did not evacuate. Papers were excluded from the meta-analysis if the study populations could not be sorted according to these criteria. After sorting, data from 82 papers were found to support the meta-analytical examination.

The reported effect sizes for each health effect were pooled using a random effects model to account for interstudy variability. Accounting for interstudy variability provides a better estimate of the true effect size when examining health effects resulting from different emergency events ranging from wildfires to nuclear power plant accidents occurring in countries all over the world. Next, a meta-analysis was performed to examine the prevalence of health effects in displaced populations and nondisplaced populations and to estimate the odds ratio of the health effect occurring in displaced populations. Where data permitted, the authors then performed a meta-regression on each of these analyses to examine which event or study variables were associated with better or worse outcomes.

This study used two statistical analyses: a meta-analysis and a meta-regression. The analyses focused on two different risk measures: prevalence of health effects and odds ratios. Prevalence was calculated to determine the occurrence of a negative health effect among nondisplaced and displaced populations. The odds ratio was calculated to understand the prevalence of the health effect in the displaced population relative to the nondisplaced population. A meta-regression was performed to examine whether specific variables, such as emergency event type or time since evacuation, were related to better or worse outcomes in displaced populations. Each of these analyses were performed for the individual health effects identified during the literature review and for all health effects combined.

The meta-analysis revealed that an increase in negative health outcomes is associated with evacuation and relocation across all identified health effects. This increase in prevalence among displaced populations was statistically significant for 9 of the 14 health effects (depression, diabetes, general health effects, mortality, PTSD, psychological distress, sleep problems, weight problems, and other miscellaneous effects). The significant variables identified in the meta-regression analysis varied between health effects but included both emergency event types and data measurement method (e.g., survey or physician diagnosis). When all 14 health effects were considered together, a pooled meta-analysis showed a significant association between evacuation and relocation and an increase in negative health effects, with an overall odds ratio of 1.49 with associated 95-percent confidence interval of (1.24–1.79). An odds ratio greater than 1 indicates an increase in negative health effects in the displaced population relative to the nondisplaced population. Since the confidence interval for this effect does not include 1, the overall odds ratio is statistically significant. The meta-regression of all health effects revealed that among all emergency events, a wildfire event was the only significant variable associated with an overall increased prevalence of negative health effects among displaced populations. These findings suggest that the response to radiological events would be no worse than other hazards.

The meta-analysis clearly demonstrates that evacuation and relocation have inherent risks affecting a substantial fraction of the affected population. The health effects brought on by emergency events can be severe and are exacerbated by prolonged displacement. These findings suggest that the inherent risks of evacuation and relocation should be considered when developing protective action strategies for radiological emergency plans to support protective actions doing more good than harm.

ABBREVIATIONS AND ACRONYMS

CDC	Centers for Disease Control and Prevention
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Mangement Agency
HHS	U.S. Department of Health and Human Services
K6	Kessler Screening Scale for Psychological Distress
NIH	National Institutes of Health
NOS	Newcastle-Ottawa Scale
NPP	nuclear power plant
PAG	protective action guide
PTSD	posttraumatic stress disorder
RE	random effects
WW2	World War 2

1 INTRODUCTION

Emergency planning for commercial nuclear power plants includes a preplanned strategy for taking protective actions within defined emergency planning zones. Predetermined protective actions for the plume exposure pathway emergency planning zone are designed to avoid or reduce dose from potential exposure of radioactive materials. The choice of protective action includes evacuation, sheltering, and the use of potassium iodide as a supplement to these actions. Evacuation is not unique to radiological emergency planning; it is widely used as a protective measure in response to many different emergency events including flooding, hurricanes, wildfires, malevolent acts, natural gas explosions, chemical accidents, and hazardous materials transport accidents.

The regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.47(b)(10) provide that, “A range of protective actions has been developed for the plume exposure pathway EPZ for emergency workers and the public…Guidelines for the choice of protective actions during an emergency, consistent with Federal guidance, are developed and in place….” In 2004, the NRC initiated a project to analyze the relative efficacy of alternative protective action strategies in reducing consequences to the public from a spectrum of nuclear power plant core melt accidents. The study is documented in NUREG/CR-6953, “Review of NUREG-0654, Supplement 3, ‘Criteria for Protective Action Recommendations for Severe Accidents,’” Volumes 1, 2, and 3 (NRC, 2007; NRC, 2008; and NRC, 2010) (hereinafter referred to as the PAR study). The PAR study provided a technical basis for enhancing protective action guidance, which was issued in November 2011, as NUREG-0654/FEMA-REP-1, Rev. 1, Supplement 3, “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants – Guidance for Protective Action Strategies,” (NRC, 2011). Supplement 3 provides a risk-informed protective action strategy development tool intended for use by nuclear power reactor licensees to develop site-specific protective action recommendation procedures and for use by offsite response organizations to develop protective action strategy guidance for decision-makers.

The U.S. Environmental Protection Agency (EPA) Protective Action Guide (PAG) Manual provides radiological criteria for consideration of protective actions. A key concept of the PAGs is that the decision to implement protective actions should be based on the projected dose that would be avoided if the protective actions were implemented (EPA, 2017). The EPA developed PAGs considering the following three principles:

(1) Prevent acute effects.

(2) Balance protection with other important factors and ensure that actions result in more benefit than harm.

(3) Reduce risk of chronic effects.

As an overarching principle, protective actions should do more good than harm. In the event of a radiological release from a nuclear power plant, evacuation has long been considered the principle protective action to reduce the dose to the population living in the surrounding area. Evacuation is a good initial response as it helps prevent additional radiological exposure to the public. However, prolonged evacuation and relocation are now known to have longer term consequences that can be more harmful than the radiation exposure. As such, these effects should be understood to gain insights for use in risk-informed protective action strategies.

The accident at the Fukushima Dai-ichi nuclear plant, initiated by the March 11, 2011, Great East Japan Earthquake, and tsunami, resulted in a number of measures to protect the public, including immediate and late evacuation. Protective measures were taken based on radiation safety considerations and the massive damage to the infrastructure and facilities following the earthquake and tsunami. At the end of 2013, more than 100,000 people were still displaced (UNSCEAR, 2013). As a result, the World Health Organization (WHO) and others began reporting on the public health consequences related to the response actions to the disaster. Protective measures resulted in a wide range of social, economic, and public health consequences. According to the WHO (WHO, 2016):

> *Similar to what was observed and reported for the Chernobyl population, the displaced Fukushima population is suffering from psycho-social and mental health impact following relocation, ruptured social links of people who lost homes and employment, disconnected family ties and stigmatization. A higher occurrence of post-traumatic stress disorder (PTSD) among the evacuees was assessed as compared to the general population of Japan. Psychological problems, such as hyperactivity, emotional symptoms, and conduct disorders have been also reported among evacuated Fukushima children. While no significant adverse outcomes were observed in the pregnancy and birth survey after the disaster, a higher prevalence of postpartum depression was noted among mothers in the affected region.*

A growing record of studies indicate that significant chronic and acute human health consequences develop after populations have been evacuated or relocated. A number of recent studies have examined the risk of evacuation and relocation following the few severe reactor accidents that have occurred worldwide. One study noted that evacuations and relocations following the incident at the Fukushima Dai-ichi nuclear power plant in Japan resulted in deaths and injuries but prevented only exposures that were too low to result in meaningful observable radiation-induced health effects (Callen, 2018). Another study quantified the value of the protective actions taken at Chernobyl in 1986 and Fukushima Dai-ichi in 2011; the quantitative analysis supported the conclusion that the majority of public relocations could not be justified on the ground of radiological health benefit (Waddington, 2017). Additional studies of the risk tradeoff between evacuation and radiation exposure, particularly when focused on special needs populations, have emphasized the importance of taking evacuation-related risks into account, and that compulsory evacuation needs to be better balanced against the radiation risk. The resounding conclusion of all of these studies is that unnecessary evacuations may have done more harm than good.

1.1 Purpose

The purpose of this report is to draw insight from relevant literature on the quantifiable health consequences of evacuation or relocation in response to an emergency event. Health effects examined included physical injuries, diseases, and behavioral health effects such as stress disorders and anxiety. The authors applied meta-analysis to the results of a literature review to determine the effect size of each health effect. A meta-regression of the data looked for any statistically significant study variables (e.g., time between the event and data collection for a particular study) that resulted in better or worse outcomes.

Protective action strategies for radiological emergencies are intended to reduce the risk to the affected population. With this goal in mind, emergency managers and decisionmakers need to balance nonradiological, evacuation-related health effects against the risks of radiation exposure. While the emergency response and medical communities have been aware for years that evacuation carries some risk of evacuation-related health effects, these effects have mostly been examined individually. This report is a much broader analysis of evacuation-related health effects, including both physical and social-behavioral health effects, reported in published studies.

1.2 Scope

This study examined a range of emergencies and events that required evacuation and included populations that were evacuated, relocated, or never left the event location. Although this study examines consequences from many emergency events, it did exclude certain types of events. Additionally, the authors developed definitions distinguishing evacuated and relocated populations that best fit the purpose of this study.

1.2.1 Excluded Emergency Event Types

The study included most emergency event types, with two categorical exceptions: (1) evacuations or displacement resulting from malicious acts and (2) displacement due to ongoing armed conflict where populations are not evacuated to truly safe areas. In both cases, the event itself has the potential to cause outsized social behavior health effects beyond those of a typical natural or technological disaster. For malicious acts, these events are designed by the bad actor to inflict terror, which could cause outsized health effects that would not reflect the harm caused by the evacuation itself. Similarly, populations evacuated due to ongoing armed conflict may be at continued risk of injury or death as a result of the conflict. This ongoing risk is likely to cause stress and anxiety far beyond what is caused by the evacuation alone. Therefore, this study excluded war-related evacuations or relocations that did not clearly remove the population from harm's way were.

1.2.2 Defining Evacuated and Relocated Populations

There are several ways to define an evacuee or a relocated individual. For this analysis, an evacuated person is defined as any person who left their home at some point due to an emergency event and returned at a later date. A relocated person is someone who permanently moved to a new location, either as a result of a hazard or simply by not returning after evacuation. A nondisplaced person is defined as someone who did not leave either permanently or temporarily as a result of the event. In studies where it was not clear whether the population was specifically evacuated or relocated, the population was simply considered displaced. If a study did not clearly distinguish between unevacuated and displaced populations (e.g., by pooling the populations together in the analysis), the study was excluded. Based on these definitions, if someone evacuated and remained away for 2 years because their home was in an uninhabitable zone but then moved back when the zone restrictions were lifted, that person would be considered evacuated. The status of a study population was defined as their status at the time of the study. For example, if a study surveyed a population while displaced, the population was considered relocated even if they ultimately returned to their homes after the study.

1.3 Background

In many emergency events, the hazard posed by the event itself far exceeds the potential harm caused by an evacuation. When an emergency event, such as a wildfire or hurricane, threatens a local population, it could be a grave mistake not to be evacuated or relocated. Technological disasters, including nuclear events, are complex and can be unpredictable. In the past, the precautionary principle would dictate that evacuation of a larger area than may be at risk is prudent, but recent studies have cast doubt on this type of thinking (Baker, 2018; Saji, 2013; Tanaka, 2015). Studies focusing on the 2011 accident at the Fukushima Dai-ichi nuclear power plant have highlighted that there can be significant harms to the physical and behavioral health of people displaced from their homes, suggesting that there might be a cost specifically associated with displacement (Hayashi, 2017; Horikoshi, 2016; Satoh, 2016b).

The Fukushima disaster has occasionally been referred to as a triple disaster, because an earthquake, tsunami, and plant failure all occurred within hours of each other (Leppold, 2016). People in and around Fukushima were instructed to evacuate to avoid radiation exposure, resulting in displacements affecting multiple prefectures and millions of people. As of 2013, approximately 1,100 disaster-related deaths had been reported, with 66.6 percent of those deaths attributable to psychosomatic fatigue (Saji, 2013). While this current study is not intended to evaluate whether evacuation was merited in that instance, past events can be used to expose the risks associated with evacuation events so that these risks can be considered for future incidents.

Previous studies have examined the negative effects of displacement using meta-analytical methods (Castle, 2001; Kett, 2005; Sanders, 2004; Uscher-Pines, 2009), but none match the extent of this study. Specifically, those reports did not quantify relationships between displacement across all health attributes. Although a few of these previous analyses have included more papers (e.g., Sanders, 2004, included 137 papers in their data analysis), this meta-analysis includes more papers than most other similar studies identified.

Compared to previous studies, this project expanded the scope of events studied to include as many different emergency and evacuation events as possible to highlight overarching conclusions about the health effects associated with displacement. By drawing from a large pool of emergency events, any circumstances unique to an event type would be offset by other events, with the resultant findings being representative of evacuations in general and not of any specific emergency (Lane, 2013; Maeda, 2018). As such, the meta-regression examined whether there were any special characteristics of an emergency event type that affected the health outcome.

Research on evacuees and relocated populations are inherently case studies; as such, there is no randomly selected control group, since a control for an evacuation would require randomly selecting people within an evacuation area to remain while the rest of the population is evacuated. Instead, studies primarily use one of three different types of controls: (1) data from a nearby population that did not evacuate (e.g., DeSalvo, 2007; Thienkrua, 2006), (2) data from the population in the years before evacuation (e.g., Dirkzwager, 2006b; Hori, 2016), or (3) data from a national average or far-off populations (e.g., Lawrence, 2019; Norris, 2004). All three control types have associated advantages and disadvantages. A small number of studies include surveys of people who refused to evacuate from areas, but the comparatively small size of these groups create similar biases (e.g., La Greca, 2019; Morita, 2018).

Using a nearby population that was not displaced is close to the ideal of a randomly selected control. This control population likely shares many of the same characteristics as the displaced population, including similar environmental exposures, demographics, culture, diet, and health; however, many characteristics, including all the above, can change with geography. For example, if the displaced area was poorer or wealthier than the unevacuated area, the population likely has different levels of access to healthcare, housing, or other resources that can affect health outcomes and their magnitude (Thienkrua, 2006). Further, the displaced population may have had greater exposure to the hazard, particularly if they were evacuated after the event struck (Munro, 2017). Health effects observed in the displaced group may, therefore, be due to their experience during the event rather than their experience after evacuation, and comparing the two groups artificially inflates the displacement-related effects.

The alternative control frequently used in the literature is health data from the evacuated community in the years before the evacuation (Sakai, 2014). This method allows a comparison of the displaced population to itself, inherently matching all of the population's demographic, socioeconomic, health, and other characteristics. Like the first method, using the same population as the control does not allow differentiation of the effects of the evacuation from the effects of experiencing the emergency event itself. In addition, as a population ages, the typical health effects also change. Even if the health data are taken the instant before the event occurs, distinguishing typical age-related health effects from the effects of displacement becomes challenging, especially if the displacement-related health effects take years to develop or resolve (Ohira, 2016a; Quast, 2018). For example, an increase in the incidence of diabetes after evacuation could be a result of the evacuation or a result of a natural onset in an aging population. Therefore, diseases typically associated with older populations must be carefully controlled in these studies.

A third option for a control population is to compare the displaced population with either the national average for prevalence of a health outcome or the prevalence within some distant community (Lawrence, 2019; Norris, 2004; Saarela, 2009; Taormina, 2008). This technique is rarely used, as the displaced population is unlikely to match the demographics and other characteristics of the general population. Additionally, the shortcomings suffered by the other control group options apply to this method as well. Consequently, the authors did not use this method to create control groups for studies that did not already have them. However, the meta-analysis includes control populations based on national averages or distant communities when they appeared in a research study that directly compared them with displaced populations.

Despite the issues discussed in this section, cohort studies can supply high-quality data that allow quantitative analysis. Because it is important not to overemphasize a single source of data, the methods selected for this analysis were designed to mitigate the weaknesses of individual studies. When many studies are pooled in the meta-analysis, the other papers compensate for the weaknesses or disadvantages of individual papers or approaches. Section 3 discusses the methodology in more detail.

2 LITERATURE REVIEW

This study started with a literature search to collect data on as many relevant emergency events and health effects as possible. The literature review gathered the data necessary to support the subsequent meta-analysis and meta-regression. This section describes the methodology and outcomes of the literature review.

2.1 Literature Review Methodology

The literature review gathered data on different emergency-related evacuations and relocations and the subsequent health effects on dislocated populations. The search was performed using a series of search strings on PubMed and Scopus, followed by a thorough review of citations from relevant papers. The database search used a series of broad search strings, such as [“disaster”+”evacuation”+”risk”], and included more specific strings to capture papers on certain emergency events, health outcomes, or populations. Specific search strings included search terms related to the following:

- emergency event types, such as “earthquake” or “hurricane”
- specific emergency events, such as “Hurricane Rita” or “Black Saturday Fire”
- health outcomes, such as “depression”

Table A-1 of Appendix A lists the searches performed. This table also gives the number of unique search results (excluding repeats from past searches) and the number of papers saved for use in the analysis.

The literature search identified 1,210 unique papers. All search results were integrated into a database for further review. Every identified paper was evaluated for relevancy by checking the title and abstract. Relevant papers were further analyzed by reviewing the full text and evaluating the study according to the Newcastle-Ottawa Scale (NOS) system.

NOS is a well-established system for assessing the quality of a study’s methodology and can be used to rate cohort studies or case studies (Wells, 2014). Most studies captured in the literature search were cohort studies that examined large groups of people exposed to various circumstances and effects from emergency and evacuation events. For cohort studies, the authors gave each paper a score between 0 and 8 by answering NOS questions related to the study methods. Such method examinations include whether the measure used would effectively capture the studied effect and whether the control population was appropriate for the experimental population. Higher scores indicate a more representative study and higher quality methods. A cutoff score of 2 was set to exclude papers that did not have a developed methodology or that could not confirm or refute a relationship between an evacuation event and a health effect.

Out of the original 1,210 papers, the authors initially determined 235 to be relevant, with a further 26 excluded on closer review for various reasons (e.g., covering material beyond the scope of this report, studies examining the same group and effect as another study). As discussed in Section 2.3, 127 additional papers were excluded, leaving 82 studies included in the meta-analysis. Figure 2-1 summarizes the literature selection process.

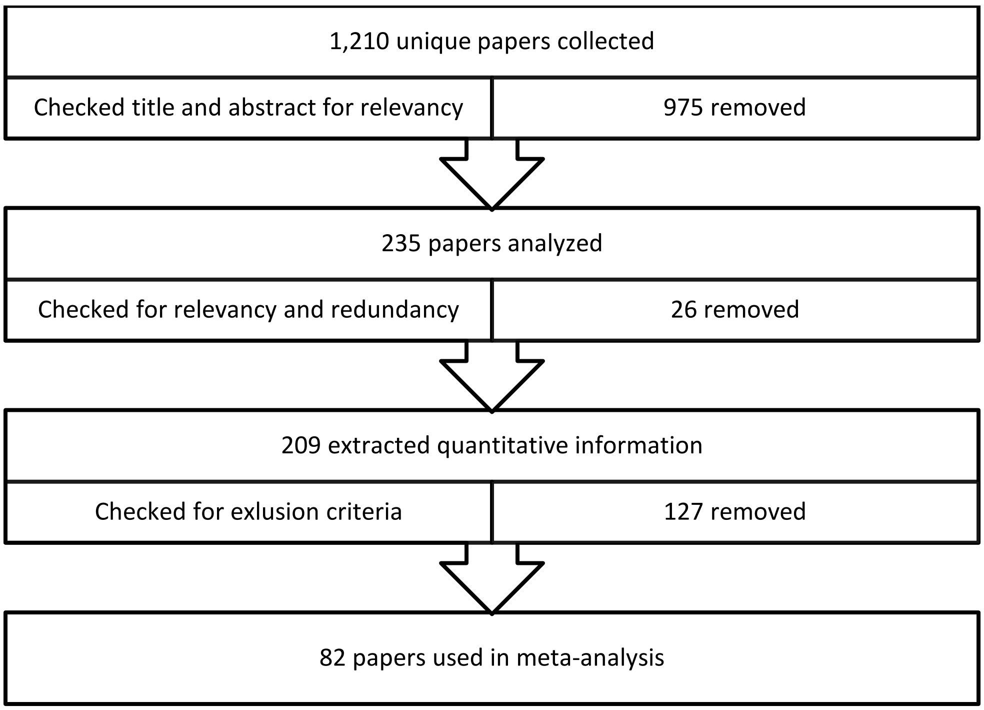

Figure 2-1 Literature Down Selection Process

After literature collection, review, and scoring, the relevant quantitative information was extracted and entered it into a machine-readable data repository. Papers were sorted into one or more rows depending on the number of groups and effects studied. Within the rows, data were organized by metadata, study parameters, and quantitative findings. Most statistical result types were collected (e.g., mean effect, pre- vs. post-disaster changes in levels, odds ratios, regression coefficients). The method of data collection within the studies was also recorded; these included administration of established tests like the Kessler Screening Scale for Psychological Distress (K6) (a validated test that measures nonspecific psychological distress over the past 30 days (Miura, 2017)), diagnosis by a medical professional, and self-reporting.

2.2 Groups for Meta-Analysis

The machine-readable database was sorted into three different study groups based on the study populations:

1. publications that examined only displaced populations
2. publications that included both displaced and nondisplaced populations
3. publications that exclusively examined nondisplaced populations

Ideally, a study would examine both a displaced population (experimental group) and a nondisplaced population (control group), but many studies did not. Instead, they might only have measurements of an effect (e.g., posttraumatic stress disorder (PTSD)) in a displaced population. Without a control group, determining the magnitude of an effect due to displacement is much more difficult, though the displaced population can be qualitatively compared with other nondisplaced groups or quantitatively analyzed in a meta-analysis. Splitting the papers into these three groups provided for a robust analysis based on the data available.

2.3 Exclusion Criteria

Publications were excluded from the meta-analysis for one or more of the following reasons:

- emergency events related to terrorism or armed conflict
- study population was so unique as to be irreconcilable with a modern-day U.S. population (e.g., hurricane survivors who also survived the World Trade Center attack (Caramanica, 2015))
- no clear distinction between displaced and nondisplaced populations when reporting health effects
- data in the publication were not usable without considerable manipulation

While the study included many types of emergency events, two types were categorically excluded: (1) displacements caused by terrorists and (2) armed conflict where populations were not evacuated to truly safe areas. In both cases, the event itself has the potential to cause outsized social and behavioral health effects beyond those associated with a typical natural or technological disaster. As the name implies, terrorist attacks are designed to inflict terror. Such events could cause disproportionate health effects that would not reflect the harm caused by the displacement itself (Bowler, 2017; DiGrande, 2008; Slone, 2009). Similarly, populations evacuated due to ongoing armed conflict may be at continued risk of injury or death due to the conflict. This ongoing risk is likely to cause stress and anxiety far beyond that caused by the evacuation alone.

The only exception to the exclusion criteria was for studies involving individuals evacuated as children to avoid conflict during World War 2 (WW2), as these were the only conflict-related studies in which the study populations were explicitly displaced to avoid violence; the other studies focused on populations displaced in direct response to the conflict. Likewise, the authors also excluded studies in which families were displaced but still at risk from an ongoing armed conflict—such as Palestinian families forcibly displaced due to conflict in Gaza (Slone, 2009). Emergency events such as those have several compounding factors that would make it difficult or impossible to isolate the effects of displacement from the conflict itself.

One strength of a meta-analysis is the ability to compare data from a variety of sources. However, some studies examined populations that were so unique that they were virtually incomparable to other groups. For example, a study tracking the PTSD patterns among the elders of an aboriginal Taiwanese community was excluded because the cultural differences were considered too great to be compared with all other PTSD-affected groups or even other PTSD-affected groups within Taiwan (Chen, 2011). Excluding studies with such specific focuses prevented those groups from unduly influencing the analysis results.

Several publications initially collected were excluded from the study groups and meta-analysis because they did not clearly distinguish between the groups of interest; for example, if data were reported for a mixed population of evacuees and nonevacuees. Results were also excluded if the data could not be made comparable without considerable mathematical manipulation (e.g., the effect size is only given as a least squares regression coefficient). After sorting the publications into the three study groups it was found that very few publications examined only nondisplaced populations following a disaster. Hence, the 82 studies in study groups one and two primarily informed the meta-analysis.

2.4 The Health Effects

The health effects of emergency events are as varied as the events that cause them, but some effects are more studied than others. The literature review identified 14 different effects, split into two general categories: broad effects and specific effects. Broad effects included those that are well known but with nonspecific and varying symptoms (e.g., psychological distress) and included a range of specific effects for which there were not enough data to merit an entire category. Specific effects included well-known and documented effects of emergency and relocation events, such as anxiety and PTSD.

2.4.1 Broad Effects

The literature review identified five broad effects:

- general health effects (18 papers)
- healthcare accessibility (5 papers)
- other effects (8 papers)
- psychological distress (23 papers)
- substance abuse (11 papers)

General health effects included changes in the health status of individuals after the emergency event, changes in blood pressure, incidence of gastrointestinal issues, and other general effects. Healthcare accessibility refers to an individual's ability to receive medical care for any reason following an emergency. The "other effects" category included several negative effects, such as memory issues or social isolation following an emergency event (Horikoshi, 2017; Taormina, 2008). Psychological distress fell in between both health-related categories, because while specific tests such as the K6 exist to recognize psychological distress among individuals, the effect is frequently used as a coverall term for any mental anguish or treated as a symptom of another disorder (Stein, 2010). Substance abuse included the increased use, abuse, or misuse of alcohol, cigarettes, stimulants, depressants, and hallucinogenic substances.

2.4.2 Specific Effects

The literature review identified nine specific health effects:

- PTSD (32 papers)
- depression (17 papers)
- heart disease (12 papers)
- anxiety (10 papers)
- diabetes (10 papers)
- mortality (8 papers)
- weight problems (6 papers)
- respiratory problems (5 papers)
- sleep problems (4 papers)

The incidence rates of anxiety, depression, and PTSD are known to be prevalent in populations following emergency events, but sometimes it is unclear to what extent they are caused by the disaster compared to the displacement (Maeda, 2018). Diabetes was considered a disaster effect if diabetes increased among an exposed population, or if treatment of diabetic patients was significantly disrupted due to the emergency and subsequent evacuation events.

Hypertension can be related to several diseases but was included along with cardiovascular diseases within the heart disease category. Mortality was considered a specific effect because it captured reports of deaths that could not be attributed to other categories, such as deaths due to heart attacks. Additionally, all mortality data in the final analysis concerned at-risk populations, such as hospital patients and nursing home residents. While there are undoubtedly mortality concerns for the general population, such as car accidents during evacuation, no mortality data for the general population from the evacuation event itself were reported in the literature reviewed. Weight problems refers to changes in weight following emergency events, whether that included weight gain or loss. Respiratory problems covered reports of respiratory disease, such as acute bronchitis. Sleeping problems were largely self-reported issues in which subjects reported having disturbed sleep, an altered schedule, or sleeping too much or too little.

2.5 The Emergencies

The meta-analysis considered a wide range of emergency events, including hurricanes, wildfires, nuclear power plants accidents, floods, chemical explosions, earthquakes and tsunamis, cyclones, war, and nonemergency relocation events. Most types of natural disasters that examined the broad and specific health effects listed in Section 2.4 were included. Some events that are not technically emergencies were also included if they still involved a significant displacement of a population, such as the state-sponsored relocation in rural China for water diversion megaprojects. One event type, termed “explosions,” represents an emergency in which a nonradioactive and unintentional blast leads to injury and displacement. Studies on the Netherlands Fireworks Disaster in 2001 made up all the explosion-type papers in the meta-analysis. The following provides the full list of emergency events, including technological and natural hazards:

- nuclear power plant accidents (32 papers)
- hurricanes and cyclones (19 papers)
- earthquakes (9 papers)
- wildfires (6 papers)
- floods (6 papers)
- earthquakes and tsunamis (3 papers)
- explosions (3 papers)
- war (3 papers)
- nonemergency relocation events (2 papers)

The meta-analysis included a wide range of emergencies for two reasons. First, there have been too few nuclear power plant events that necessitated evacuations to serve as a basis for a full meta-analysis. Although the Chernobyl and Fukushima Dai-ichi accidents are well studied, because of the cultural, situational, and technological differences, neither of these events are entirely reflective of what a nuclear power plant accident in the United States might look like. Moreover, while the effects of the Fukushima disaster are particularly well reported thanks to the Fukushima Health Management Survey, the scope of effects is relatively limited. Consequently, the range of included emergency evacuations was expanded beyond nuclear power plant events. Second, the wide range of disaster types allowed for a broad view of displacement following emergencies and can help determine if there are trends in effects that were more associated with evacuation or relocation than the nature of the disaster itself.

3 METHODOLOGY

This section describes the meta-analysis and meta-regression methods used to analyze the data gathered from the literature review. The literature search gathered data on negative health outcomes in displaced and nondisplaced populations following emergency events. The meta-analysis and meta-regression methods used data from these prior studies of emergency events to give unique insights into health effects related to evacuation and relocation.

The differences in negative health outcomes were examined by aggregating the available quantitative data into a pooled, population-level health effect size. This was accomplished by first collecting and processing the data from the literature review for inclusion into the meta-analysis. Data were evaluated for inclusion in the analysis based on the characteristics of the health outcomes and the quantity and quality of the data. Next, a weighted average of the size of health outcome effects (effect size) was estimated using meta-analytic techniques. After a pooled effect size for each health outcome was calculated, a meta-regression was performed to examine study-specific factors associated with an increase or decrease in pooled effect size. Meta-analysis and meta-regression both rely on random effects modeling to compute a weighted average of health outcome effect sizes (Cuijpers, 2016). Sections 3.1 and 3.2 describe these methods in detail.

3.1 Meta-analysis

3.1.1 Random Effects Modeling for Meta-Analyses

Meta-analysis refers broadly to a family of statistical methods that can be used to combine data from individual studies. These methods can be used to pool information already gathered by scientists and to increase statistical power by increasing an effective sample size. Meta-analytic techniques include a family of models used to estimate an aggregate weighted average from multiple studies. These weighted averages estimate the size of a health effect for a general population under a given condition (such as evacuation following an emergency event). This report refers to these weighted averages as “effect size statistics” or just “effect sizes.” An example of an effect size might be a proportion estimate of the affected population (e.g., 30 percent, or 0.30, of the sample population experienced health effect X). This section includes examples to help with interpretation of results in later sections.

Random effects (RE) modeling was used to estimate an overall, population-level effect size for each health outcome. An RE model is a statistical model that makes explicit the assumption that individual effect sizes vary due to both sampling error (within-study variance) and an underlying difference in study design or study populations (between-study variance) (Borenstein, 2009). This method was used instead of a fixed effect model—which assumes the variance is only due to sampling error—because the data for the meta-analysis come from studies performed on many different populations, in different countries, and affected by different emergency events. RE models use this underlying assumption to calculate a weighted average effect size:

$$m = \frac{\sum_{i=1}^{k} W_i Y_i}{\sum_{i=1}^{k} W_i} \qquad (3\text{-}1)$$

In Equation 3-1, m represents the weighted mean effect size computed for each health outcome. Y_i represents each observed study effect, and W_i represents the weight assigned to each study. In RE modeling, the weights W_i (Equation 3-2) are estimated as a combination of the within-study variance for each study and an estimate of the between-study variance:

$$W_i = \frac{1}{V_{Y_i} + T^2} \quad (3\text{-}2)$$

The within-study variance V_{Y_i}, also referred to as sampling error, is the error that results when the sample size collected is not equal to the whole population. V_{Y_i} was calculated for each study included in the meta-analysis. The between-study variance, T^2, is the size of the variance due to underlying differences in the sample populations included in each study.

Greater variability in an individual study effect size decreases the study's weight when the overall average effect size is calculated. In this way, studies with larger sample sizes (for example, a study of 10,000 evacuated people surveyed following the Fukushima disaster) will tend to have smaller within-study variance estimates, causing their individual contributions to the aggregated effect size to be more heavily weighted than studies with greater within-study variance. Similarly, greater variability in the individual-study effect sizes used for each RE model will increase the estimate of the between-study variance. RE models can be used to aggregate different types of effect sizes. Additionally, depending on the type of effect size, different methods can be used to estimate the within- and between-study variance for each RE model. Decisions about method implementation (i.e., selecting a method to estimate between-study variance) were made based on general best practices for the specific types of effect size statistics and characteristics of the data (Veroniki, 2016). The following sections describe the difference between an analysis of population proportion effect sizes and odds ratios and the models used to analyze these types of study effect sizes.

3.1.2 Proportion Analysis

Proportion analysis estimates the proportion of affected displaced individuals with no comparison population (nondisplaced). It may also be referred to as the prevalence of a health condition in affected populations. The proportion of affected displaced individuals for each health outcome was synthesized across studies using the metafor package in the statistical programming language R (Viechtbauer, 2010). For each health outcome, the arcsine square root transformation function was used to transform the proportion of affected individuals reported in studies to obtain values that have an approximately normal sampling distribution (Barendregt, 2013). This transformation enables a better approximation of the sampling variance (Miller, 1978). An RE model was then used to estimate a summary effect size and standard error/confidence interval of the transformed proportion data. In the RE analysis, a common method, known as the DerSimonian and Laird method, was used to estimate between-study variance using inverse variance weights for each study (DerSimonian, 1986; Seide, 2019). These estimates are visualized using a forest plot, which shows the individual effect sizes and the individual-level variance of each study, along with the final pooled estimate and 95-percent confidence interval.

Figure 3-1 shows an example forest plot for visualizing individual study contributions to the aggregate proportion effect size for PTSD. The final estimate (95-percent confidence interval) is $\hat{p} = 0.32\ (0.25, 0.39)$. These results can be interpreted as a pooled estimate of the proportion of individuals exhibiting specific health effects in the aftermath of an emergency event. In this example, roughly 32 percent of displaced individuals reported symptoms of PTSD following an event. The individual studies contribute to the final estimate, though not all equally. The individual study inverse variance weights are not reported in this analysis; however, Figure 3-1 demonstrates the relative size of the confidence intervals around each individual study effect. A wider confidence interval (e.g., Acierno, 2007) indicates an individual effect size with higher variance and thus lower inverse variance weights. A smaller confidence interval (e.g., Brown, 2019) indicates studies with lower variance and thus higher inverse variance weights. Individual studies may have drastically higher or lower reported prevalence than the pooled estimate, but these differences are likely to be a result of sampling bias (as compared to the population of all people who have ever evacuated) or the specific nature of the study being carried out. Pooled proportion estimates can be used to compare the relative size of negative health outcomes to other health outcomes and can be used to understand a broad population effect in the absence of a nondisplaced comparator population in individual studies. For example, the estimated proportion of displaced individuals who might experience symptoms of PTSD can be compared to the estimated proportion experiencing symptoms of depression following an emergency event.

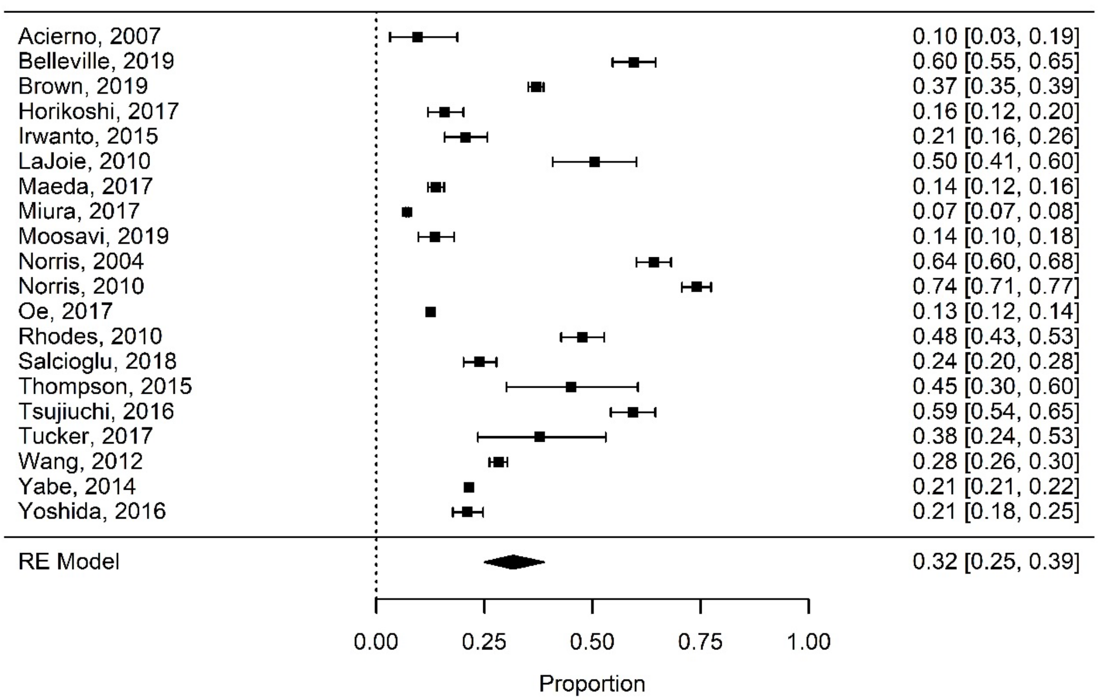

Figure 3-1 Example Forest Plot for Proportion Effect Sizes for PTSD in Displaced Populations

The prevalence of negative effects of evacuating or relocating individuals in response to a manmade or natural disaster can be quantified in the displaced populations. However, with proportion analysis there is no way to tell whether these populations would have exhibited the same negative health consequences had they not evacuated or relocated following an event. Therefore, the analysis is supplemented with qualitative data from the literature review and subject matter expertise to give additional insight on health outcomes in the aftermath of emergency events. Prevalence data are also reported alongside odds ratio effect sizes, where comparison populations are available at the individual-study level to allow direct analysis of the relative effects of displacement.

3.1.3 Odds Ratio Analysis

An odds ratio can be used to ascertain whether an exposure is associated with or is a risk factor for a specific outcome. This study used odds ratios to identify whether specific health effects (outcomes) were associated with displacement (risk factor). While odds ratios are well suited to this analysis, they cannot be used to estimate the number of people affected by that outcome following an emergency event, nor can they provide the relative risk of that outcome (e.g., outcome X is four times more likely in the displaced population). In the studies used in this analysis, odds ratios are useful for comparing the outcome of displaced populations to nondisplaced populations within a study. The pooled odds ratio is an estimate of the odds that an outcome (e.g., an individual experiences symptoms of PTSD) will occur if someone is evacuated or relocated following an emergency event, compared to the odds of the outcome occurring if someone is not evacuated or relocated following the event. The odds ratio of affected displaced individuals for each health outcome was synthesized across studies using an RE model to compute a summary effect size. For each health outcome, the individual studies either included count data from affected individuals in both displaced and nondisplaced groups or reported odds ratios and associated confidence intervals.

Table 3-1 Count Data Used to Calculate Odds Ratios

	Experienced negative health outcome	Did not experience negative health outcome
Displaced	N_d	H_d
Nondisplaced	N_n	H_n

Table 3-1 illustrates how count data were extracted and enumerated from individual studies of negative health outcomes experienced by displaced and nondisplaced populations following emergency events. In this table, N_d and N_n represent the number of displaced and nondisplaced individuals who reported the presence of a negative health outcome, respectively. H_d and H_n represent the number of displaced and nondisplaced individuals who reported the absence of a negative health outcome, respectively. These count data were then used to compute individual-study level odds ratios ($\widehat{OR}$), as shown in Equation 3-3.

$$\widehat{OR} = \frac{N_d/H_d}{N_n/H_n} \qquad (3\text{-}3)$$

All computed or extracted odds ratios from individual studies were transformed into log-odds to enable a better approximation of the sampling variance (Chang, 2017). The log transformation is a best practice procedure for the treatment of ratio effect size statistics and associated variance to maintain symmetry about a null ratio of 1.0 (Borenstein, 2009). RE models were used to estimate a summary effect size (mean) and standard error/confidence interval of the transformed odds ratio data. The empirical Bayes method was used to estimate between-study variance, and the weighted option was specified, meaning individual effect sizes are weighted according to their inverse variance (a measure of within-study variance) (Raudenbush, 1985). These estimates were then visualized using a forest plot, which shows the individual effect sizes and the individual-level variance of each study, along with the pooled estimate and 95-percent confidence interval.

Figure 3-2 shows an example forest plot used to visualize individual study contributions to the aggregate odds ratio effect size estimated using a random effects model. Odds ratios allow an examination of the strength of a relationship between conditions. In this analysis, the odds ratio shows the association between negative health outcomes (e.g., experiencing PTSD) and displacement following an emergency event. Estimated odds ratios equal to 1.0 are evidence of independence between the negative health outcomes and displacement; that is, displacement following an emergency has no known association with an increased likelihood of experiencing a particular outcome. If an estimated odds ratio is less than 1.0, it can be inferred that, in the absence of displacement, there is a greater likelihood of experiencing a negative health outcome. If an estimated odds ratio is greater than 1.0, it can be inferred that, in the presence of evacuation or relocation, there is a greater likelihood of experiencing a negative health outcome.

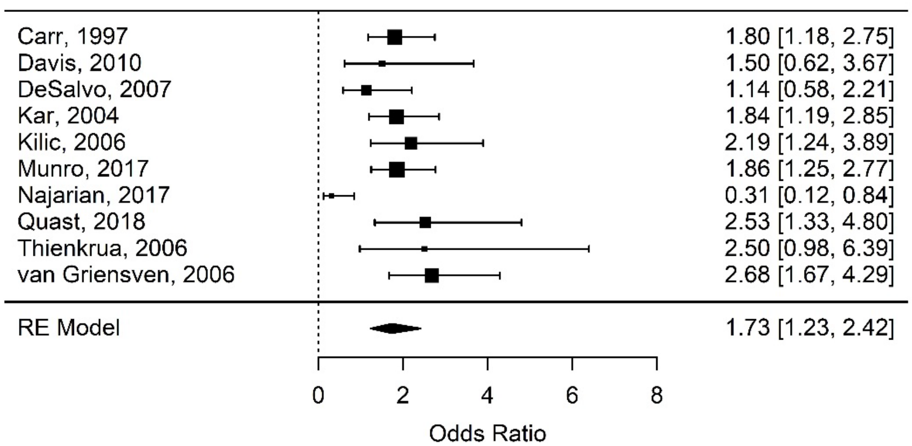

Figure 3-2 Example Forest Plot for Odds Ratio Effect Sizes for PTSD in Displaced Populations

Exploring negative health outcomes using pooled odds ratio estimates enables the study of possible negative outcomes in populations following decisions about displacement. However, due to the vast differences in the data used across these observational studies, care should be taken when interpreting these results. It is possible to examine the overall PTSD effect size and conclude, with some confidence, that there is evidence that the odds that an individual might report or be diagnosed with symptoms of PTSD following an emergency event are greater if displaced following the event than if not displaced (refer to Section 4.1.8). However, the diversity of emergency events included in the PTSD meta-analysis means that at an individual emergency type level, the conclusions may not hold. To examine the possible influence of event type (e.g., floods, hurricanes) and other emergency and study characteristics on the estimated pooled effect sizes a meta-regression was conducted for each broad health outcome.

3.2 Meta-regression

In the meta-analyses described in Section 3.1, individual study effect sizes were considered for inclusion based on study quality, emergency event type, and information included in each study (e.g., how odds ratios were calculated). However, several different event types across a broad time frame (1940s–2010s) and health outcomes involving data gathered using different survey techniques were all considered for inclusion. A meta-regression study was conducted to examine the individual study and emergency event characteristics that are associated with greater or lesser pooled effect sizes across each health outcome.

This method involves mixed effects modeling where the study factors (e.g., emergency type, time between emergency event and data collection, year study was published) were individually analyzed as moderator variables, while between- and within-study variance is accounted for under the RE model. Mixed effects model procedures use methods similar to the ones described in the RE method but also include study characteristics as an individual moderator variable in each univariate model, as described by Christensen (1987):

$$y_i = \beta_0 + \beta_1 x_{1i} + \eta + \varepsilon \qquad (3\text{-}4)$$

In Equation 3-4, y_i once again represents the individual study effect size, while the added terms β_0 and β_1 allow for the estimation of a moderator variable effect size. The model coefficient, β_1, is estimated as the slope of the regression equation and can be interpreted as the estimated increase (or decrease) on the study effect size given a change in the moderator variable. For continuous moderator variables, such as "time between emergency event and data collection," the model coefficient indicates the estimated change in the study effect size given a one-unit (e.g., year) increase in the moderator variable. For discrete moderator variables, such as a categorical variable indicating the type of study data source, the model coefficient indicates the estimated change in the study effect size for categories when compared to a reference variable. For the type of study data source example, the model coefficient would indicate the estimated change in the study effect size when the data source is "data collected via a test" compared to "data collected via a physician diagnosis." For these discrete variables, the reference values are reported alongside the data. The moderator variable effect size supports an understanding of whether the total aggregate effect size depends on this variable.

The meta-regression examines which study characteristics are contributing more or less to pooled effect sizes, which in turn can help guide interpretation of the pooled results. For example, if greater PTSD odds ratios are expected on average when the emergency event type is a flood, guidance might be modified for flood evacuations relative to other emergency evacuations. In the absence of statistically significant associations, the conclusion will be that there is not enough evidence to make emergency event-type specific guidance. The study characteristics examined include data source (i.e., whether the health outcome was measured by a physician, a test, or a self-reported diagnosis), group type (evacuated only, relocated only, or both displaced populations together), and NOS score indicating study quality (discussed in Section 2), the time between the emergency event and data collection, and the event type (e.g., earthquake, flood, hurricane). Table 3-2 summarizes the moderator variables.

Once all the study characteristics were evaluated in individual models, the results were aggregated across the health outcome to compare model coefficients and *p*-values. If the forest plot does not include a variable, it is because no included studies contained with that variable or emergency characteristic for the specified health outcome meta-regression. Figure 3-3 is an example of an odds ratio meta-regression to examine study characteristics with evidence of association with the pooled PTSD effect size. The x-axis displays each model coefficient, and the y-axis displays the *p*-value associated with each model coefficient. Table 3-2 describes factors in the legend: the reference variable for the group factor is both evacuated and relocated populations (ref: Both); the reference variable for the source factor is physician-diagnosed cases (ref: Physician). A statistical significance level of $p = 0.05$ was used to examine the individual study characteristics (plotted using a horizontal line for reference). An estimate of a model coefficient with *p*-value < 0.05 indicates a coefficient that is significantly different from zero, which means that there is a positive or negative change in the expected health effect when this variable changes. In this example plot, the only statistically significant model coefficient is "time between event," which refers to the study characteristic of how much time passed between the original emergency event and data collection. Because this variable is numeric, the model coefficient can be interpreted as the expected change in the average odds ratio effect size given a one-unit increase in time (in this example, 1 year). Since the model coefficient is statistically significant and less than zero, it can be taken to mean that as the time between the event and data collection increases, the expected average PTSD effect size will decrease.

Table 3-2 Moderator Variables Analyzed in Meta-regression Models

Variable Short Name	Type of Variable	Variable Values
data_source	Categorical	Physician-diagnosed (reference), self-reported, test
group	Categorical	Both evacuated and relocated (reference), evacuated, relocated
NOS	Numeric	Ordinal NOS score values 2–8
time_between_event	Numeric	Years (numeric values >0) between event and effect measurement
type_CycHurr	Binary	Cyclone or hurricane emergency indicator
type_EqTsu	Binary	Earthquake or tsunami emergency indicator
type_Flo	Binary	Flood emergency indicator
type_Fire	Binary	Fire emergency indicator
type_NPP	Binary	Nuclear power plant emergency indicator

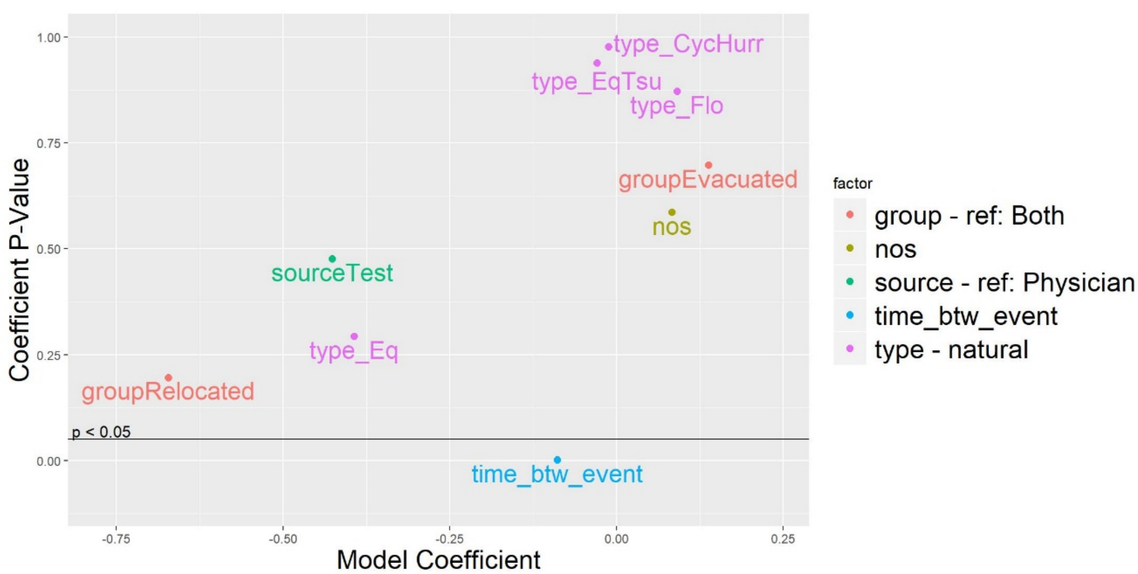

Figure 3-3 Example of Odds Ratio Meta-regression for PTSD

The meta-regression analysis aids the examination of whether specific study characteristics are contributing to pooled effect sizes, which guides the interpretation of the pooled results. In the absence of statistically significant associations, the conclusion will be that there is not enough evidence to make emergency-type-specific determinations. If there is evidence of statistically significant associations, especially for emergency types, these results could be used to guide recommendations for specific types of emergency events. Section 4 explores results from the meta-regression analyses for each health outcome at the level of individual health outcomes.

4 ANALYSIS AND FINDINGS

This section describes the results of (1) the meta-analysis of the odds ratio and prevalence data and (2) the meta-regression for each health effect. After discussing the separate health effects in alphabetical order, the section ends by considering all outcomes together. Table 4-1 summarizes the odds ratio meta-analysis for each health effect, the associated 95-percent confidence intervals, and whether the finding is statistically significant. Each of the odds ratios compares the prevalence of the health effect among displaced populations with respect to populations that did not evacuate or relocate. The odds ratio effect size was greater than 1.0 (statistically significant at the 0.05 level) in 9 of the 14 meta-analyses, indicating a greater likelihood that displaced individuals experience negative health outcomes compared to nondisplaced individuals. These associations between effects and displacement are significant because the 95-percent confidence interval for the odds ratio does not include 1.0, meaning that it is very unlikely that the effect is the same in both the displaced and nondisplaced population. Of note is that even for effects that were not statistically significant, the estimated odds ratios were greater than 1.0.

Table 4-1 Summary of Odds Ratio Meta-analysis for Each Health Effect

Health Effect	Odds Ratio	95% Confidence Interval	Statistical Significance (*p*-value)
Anxiety	1.29	(0.84, 1.97)	
Depression	2.50	(1.87, 3.35)	< 0.001
Diabetes	1.19	(1.08, 1.32)	< 0.001
General Health Effects	1.94	(1.14, 3.30)	< 0.05
Healthcare Accessibility Problems	2.04	(0.81, 5.18)	
Heart Disease	1.07	(0.88, 1.31)	
Mortality	1.76	(1.49, 2.09)	< 0.001
Posttraumatic Stress Disorder	1.73	(1.23, 2.42)	< 0.01
Psychological Distress	1.68	(1.19, 2.38)	< 0.01
Respiratory Problems	1.48	(0.96, 2.30)	< 0.1
Sleep Problems	1.63	(1.53, 1.74)	< 0.001
Substance Abuse	1.11	(0.97, 1.27)	
Weight Problems	1.43	(1.17, 1.75)	< 0.001
Other Effects	2.86	(1.81, 4.52)	< 0.001
All Health Effects	1.49	(1.24, 1.79)	< 0.001

4.1 Health Effect-Specific Findings

4.1.1 Anxiety

Anxiety is an activated state of worry or apprehensive expectation, often combined with fatigue and sleep disturbance (from the cognitive demands of the activated state), restlessness, poor concentration, irritability, and muscle tension. The anxiety-specific odds ratio analysis, conducted on three studies shown in Figure 4-1, identified an odds ratio of 1.29, suggesting an increase in prevalence in anxiety as result of displacement following an emergency. Although reported in greater frequencies in displaced populations, anxiety is still present in the nondisplaced population as well. Figure 4-2 and Figure 4-3 show the proportion of people who have reported anxiety in the displaced and nondisplaced populations, respectively. This finding was expected, as previous studies have shown that anxiety following emergency events is mediated primarily by exposure to the traumatic event itself, rather than to factors related to evacuation (Davis, 2010). Getting away from the event or being rescued from it or avoiding significant risk may decrease anxiety. For others, remaining in place may decrease their anxiety about protection of property. Ultimately, however, anxiety is a symptom of many other health effects, including PTSD and psychological distress, so any relief of anxiety caused by displacement (or nondisplacement) from the hazard may ultimately be temporary before other stressors begin to cause anxiety again.

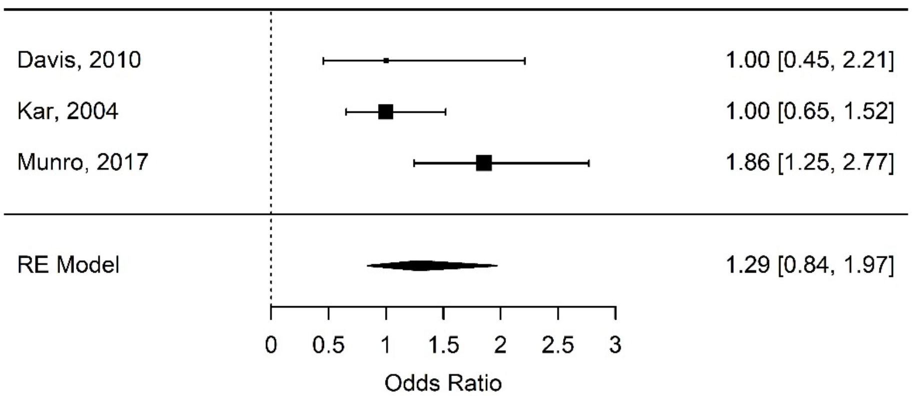

Figure 4-1 Meta-analysis of Odds Ratio for Anxiety

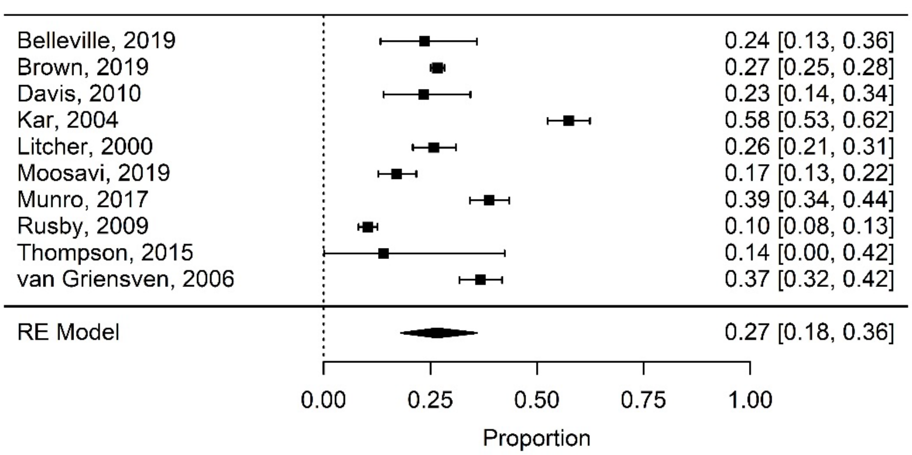

Figure 4-2 Prevalence of Anxiety in Displaced Populations

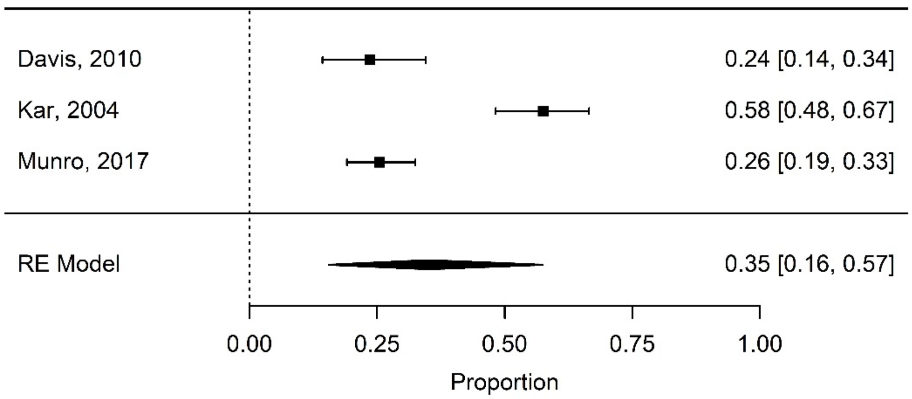

Figure 4-3 Prevalence of Anxiety in Nondisplaced Populations

For the meta-regression, one variable—the type of emergency event—had a significant association with the anxiety outcome, as shown in Figure 4-4. Specifically, two emergency event types were associated with either increases or decreases in the expected number of individuals reporting anxiety. Cyclones and hurricanes were associated with fewer expected cases of anxiety, while floods were associated with a greater number of expected cases of anxiety. Cyclones and hurricanes are typically associated with several days of warning, providing affected populations time to prepare both physically and psychologically, so it is reasonable that this emergency type is associated with less reported anxiety. Floods, on the other hand, include flash floods that typically come with very little or no notice. The two other types of events in this dataset, earthquakes and tsunamis, were combined into a single category and are a combination of both no-notice (earthquake) and short-notice (tsunami) events; insufficient data were available to examine the two emergency events separately.

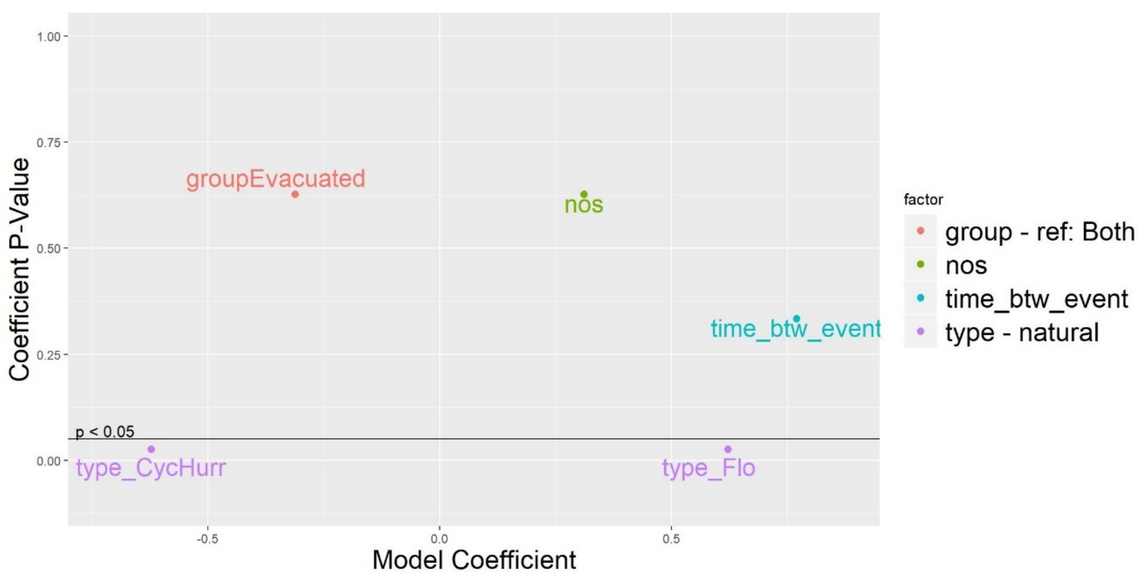

Figure 4-4 Meta-regression of Odds Ratio for Anxiety

This apparent relationship with notice does not appear in the prevalence data for either the displaced or nondisplaced populations shown in Figure 4-5 and Figure 4-6, respectively. In these meta-regressions, no study variable was statistically significantly associated with the prevalence of anxiety in the displaced or nondisplaced populations. For floods, this finding suggests that the relationship observed in the odds ratio meta-regression could be caused by a small effect in both populations in the same direction but of different magnitudes. For example, the effect could be caused by a small increase in anxiety in the displaced population and a slightly smaller increase in the nondisplaced population. Individually, neither of these effects may be significant, but when compared against each other they show a statistically significant association. For hurricane events, there was evidence that both displaced and nondisplaced populations saw an increased prevalence of anxiety compared to nonhurricane evacuation events, although neither was statistically significant. This effect may only be detectable in the odds ratio dataset because the data for the displaced and nondisplaced populations used to calculate the odds ratio come from the same study and, therefore, the same emergency event. Overall, this finding suggests that while anxiety may not be significantly associated with displacement for all emergency events, it may be significant for some event types. More studies would be required to test this hypothesis and examine other factors, such as preparedness, loss of property or life, personal injury, and others, that may influence anxiety in displaced populations.

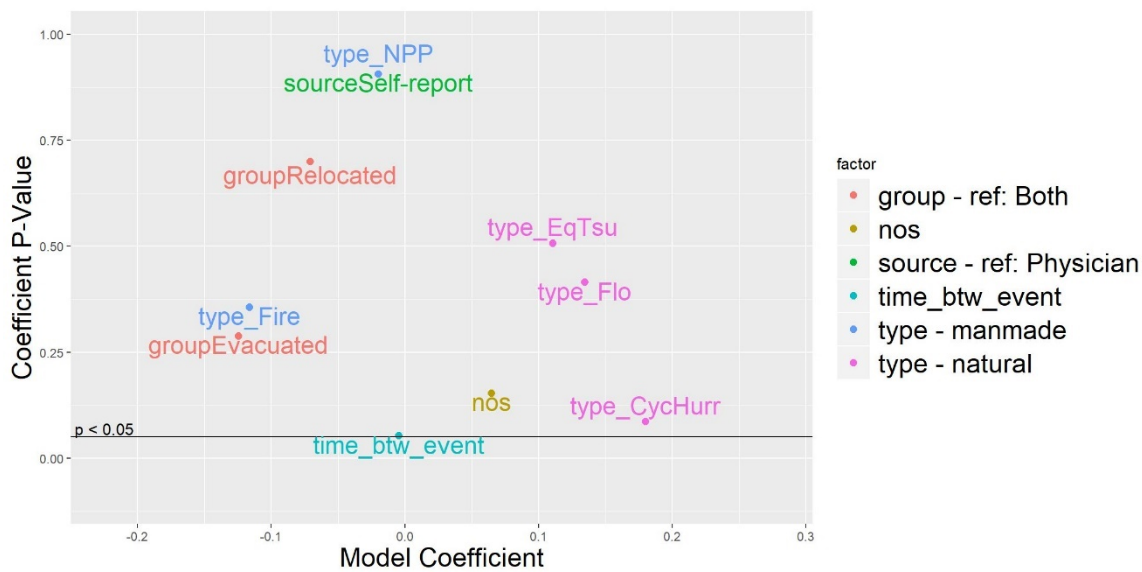

Figure 4-5 Meta-regression of Prevalence of Anxiety in Displaced Populations

Figure 4-6 Meta-regression of Prevalence of Anxiety in Nondisplaced Populations

4.1.2 Depression

The hallmarks of clinical depression are a depressed mood, loss of interest or pleasure, feelings of worthlessness or excessive guilt, and fatigue or less energy. As apprehensive expectation gives way to the emerging reality of the event, a loss of purpose, drive, or vitality sets the stage for depression and a host of symptoms: hopelessness, helplessness, anhedonia, weight fluctuations, psychomotor retardation (moving less), fatigue, poor concentration, and thoughts of suicide (Pescosolido, 2010). Based on the evidence gathered in seven studies, there is a positive and statistically significant association between reporting symptoms of clinical depression and displacement (Figure 4-7). The 95-percent confidence interval (1.87, 3.35) and the size of the odds ratio (2.50) suggest that depression is strongly associated with displacement. This finding is borne out in the prevalence data for displaced populations and nondisplaced populations, shown in Figure 4-8 and Figure 4-9, respectively, which have dramatically different average rates of depression symptoms (0.27 and 0.14, respectively). Studies of subpopulations have shown that certain population groups are at higher risk than the general population. Older adults, for example, are at a higher risk of depression (among other effects) when their routines are disrupted and they must stay in shelters (Holle, 2019). Both displaced and nondisplaced individuals may differ in their resilience in the aftermath of an emergency event. Working through loss and effectively connecting with others who are also affected can occur in both those who are displaced (if not dispersed) and those who remain. This fact is reinforced by multiple studies showing that isolation and low social support are significant factors in worsened health outcomes, including both socio-behavioral health outcomes and physical illnesses such as cancer (Carr, 1997; Horikoshi, 2017; Ozaki, 2017).

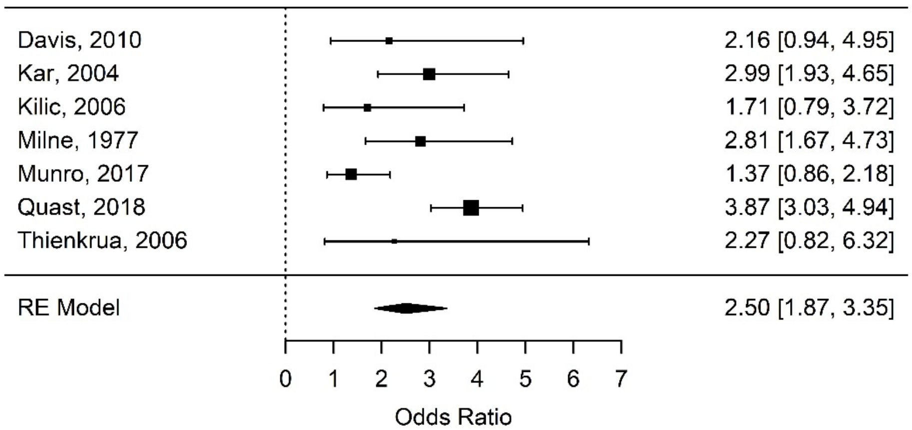

Figure 4-7 Meta-analysis of Odds Ratio for Depression

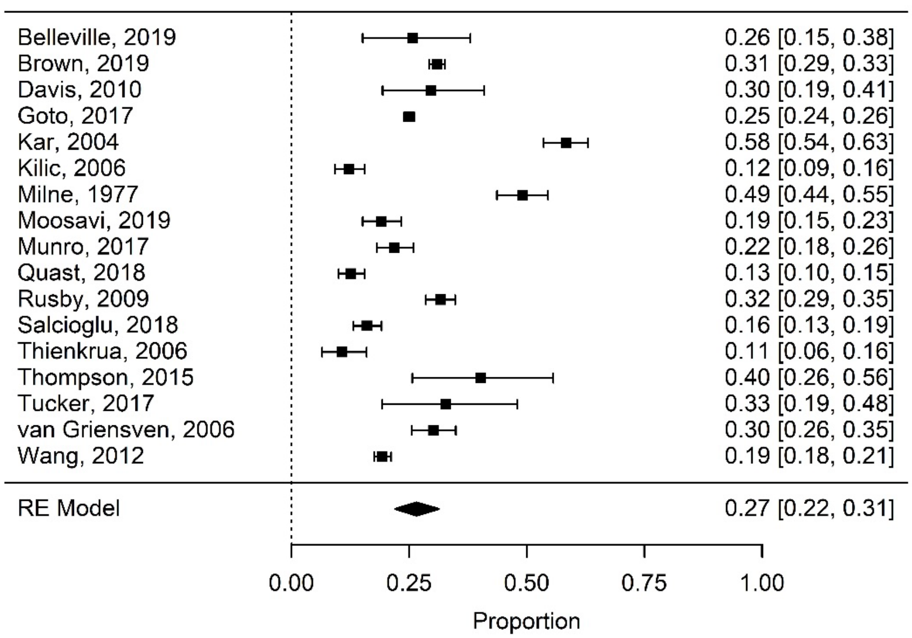

Figure 4-8 Prevalence of Depression in Displaced Populations

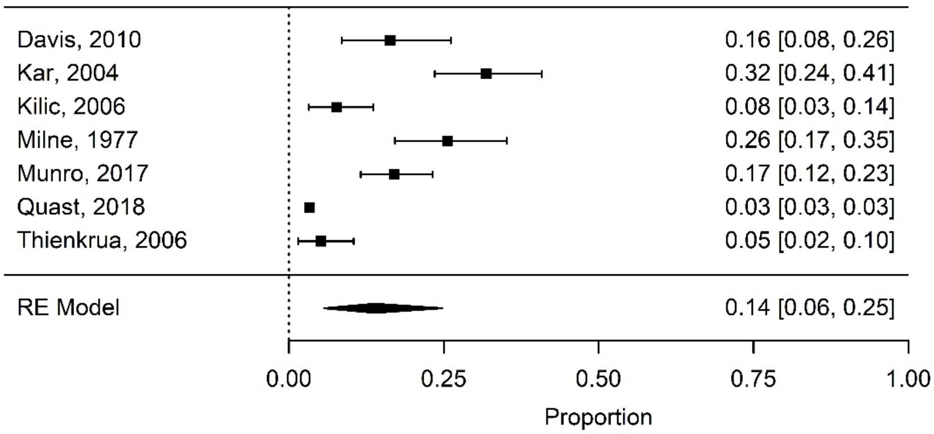

Figure 4-9 Prevalence of Depression in Nondisplaced Populations

A meta-regression of the odds ratio dataset revealed several additional considerations. The meta-regression, shown in Figure 4-10, found a small but significant reduction in depression in studies that used standard depression tests compared to studies that only included physician-diagnosed depression. The direction of this effect (i.e., lower odds ratio) is interesting because, as seen in other effects in this section, health effects are generally overreported if they rely on self-reports by study participants. This drop in odds ratio with self-reporting may be due to overreporting by nondisplaced populations. Although the relationships are not significant, the meta-regression of depression prevalence shows a greater effect of using a test to measure depression (sourceTest) in nondisplaced populations than in displaced populations, as shown in Figure 4-11 and Figure 4-12, respectively. The meta-analysis of displaced populations also identifies three statistically significant variables associated with depression: the earthquake, tsunami, and hurricane event types. The cyclone/hurricane emergency type is associated with increased depression symptom prevalence, while both earthquake/tsunami and earthquake events are associated with decreased prevalence of depression symptoms. These findings—specifically, an increase in the odds ratio for depression following cyclone/hurricanes and a decrease following earthquake/tsunamis in relation to the all-hazards effect—are mirrored in several other health effects studied in this report, although they are generally not statistically significant.

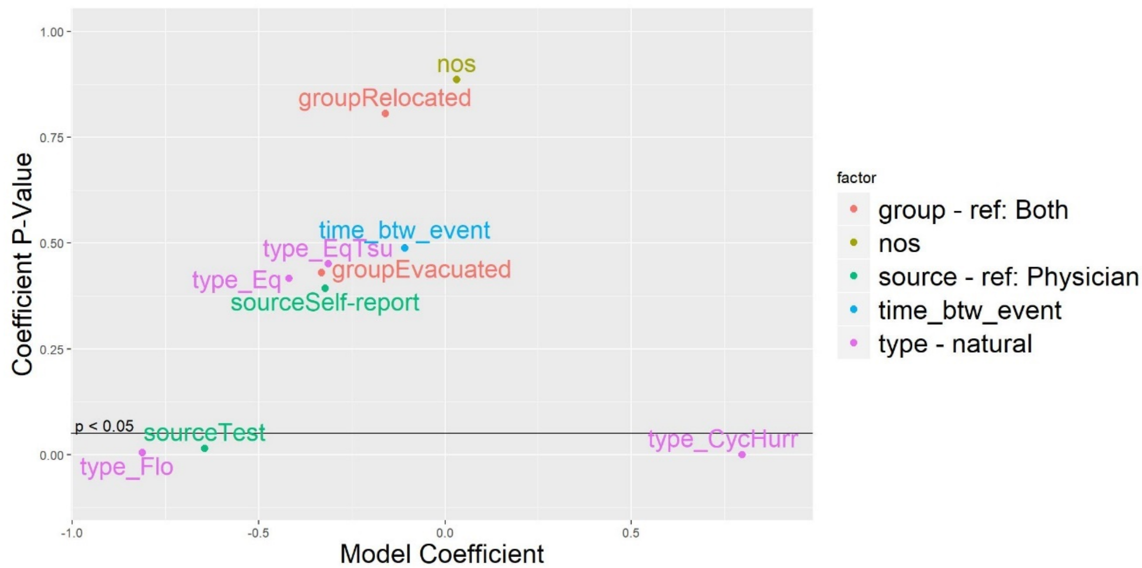

Figure 4-10 Meta-regression of Odds Ratio for Depression

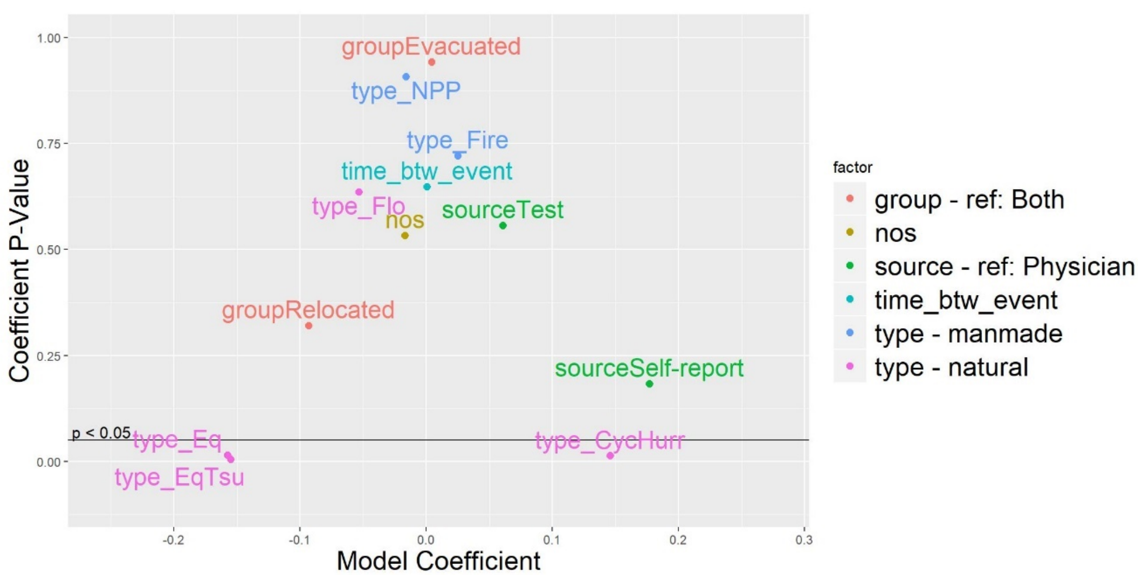

Figure 4-11 Meta-regression of Prevalence of Depression in Displaced Populations

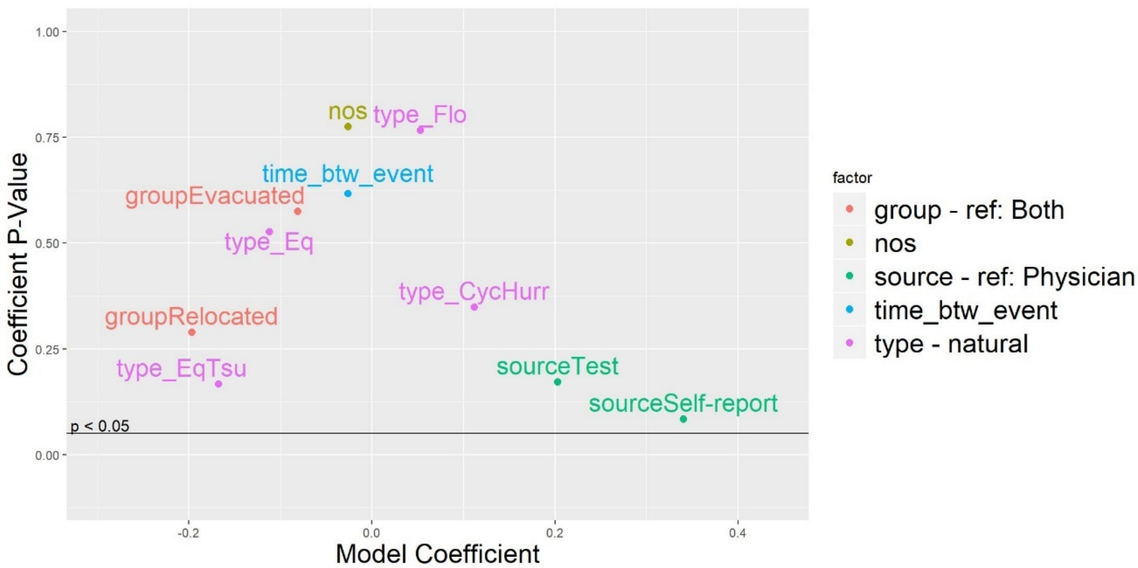

Figure 4-12 Meta-regression of Prevalence of Depression in Nondisplaced Populations

4.1.3 Diabetes

Diabetes is a disease in which blood glucose or blood sugar levels are too high, caused by either insufficient production of insulin or an impaired cellular response to insulin. Most studies included in this analysis examine the prevalence of all types of diabetes—including type 1, type 2, and gestational diabetes—among both displaced and nondisplaced populations at the time of the study. The available studies do not necessarily distinguish new cases of diabetes from diabetes that predated the emergency event, but there are studies that explicitly examined new cases (Ohira, 2017). Additionally, because of the ways prevalence was reported, insufficient information was available to distinguish between the types of diabetes present in the population. The diabetes meta-analysis, shown in Figure 4-13, found a small but significant increase of diabetes among displaced groups. The prevalence estimates among displaced and nondisplaced groups, however, are very similar, as shown in Figure 4-14 and Figure 4-15. Despite the statistically significant relationship, it is not clear from the meta-analysis alone whether there is a causal link between evacuation and diabetes or whether they merely are correlated.

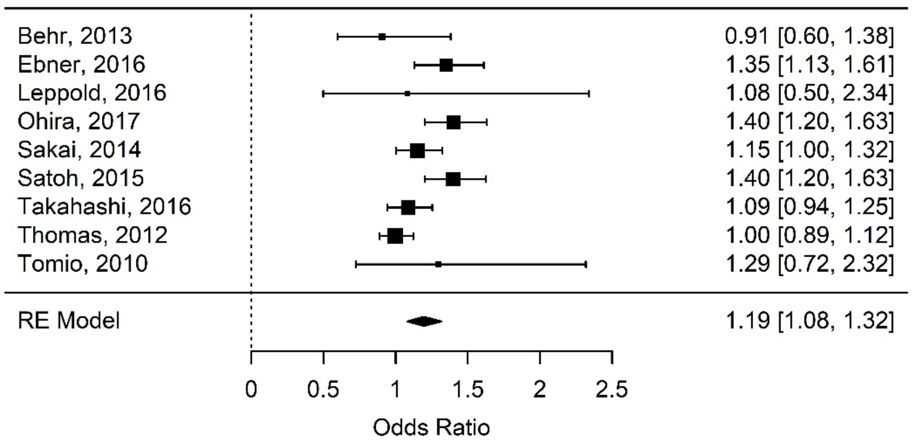

Figure 4-13 Meta-analysis of Odds Ratio for Diabetes

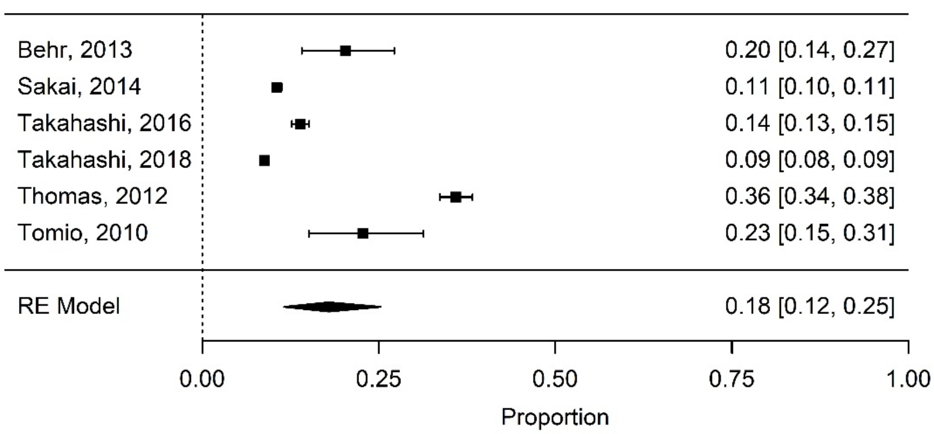

Figure 4-14 Prevalence of Diabetes in Displaced Populations

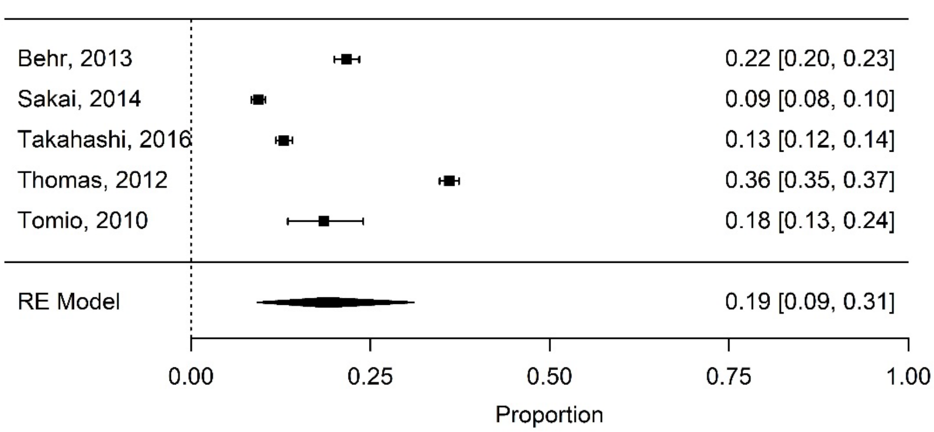

Figure 4-15 Prevalence of Diabetes in Nondisplaced Populations

The meta-regression provides additional insight. The meta-regression of the diabetes data revealed several statistically significant emergency event variables associated with increased or decreased prevalence of diabetes among displaced or nondisplaced populations. The odds ratio meta-regression shows that a higher odds ratio was associated with two factors: (1) longer times between the event and when the data was collected, and (2) nuclear power plant disasters (Figure 4-16). Conversely, the meta-regression showed that lower odds ratios were associated with cyclones or hurricanes. The nuclear power plant studies for diabetes in this analysis primarily came from the Fukushima Dai-ichi accident in 2011, which was accompanied by substantial infrastructure damage due to the tsunami and caused prolonged displacement. It is possible that infrastructure damage led an outsized proportion of the population with diabetes to evacuate, especially if their typical medical or pharmacy care was disrupted (Tomio, 2010). At least four studies examining evacuees from Fukushima showed an increased incidence of diabetes in evacuated populations (Ebner, 2016; Ohira, 2017; Satoh, 2015; Takahashi, 2016). These studies suggest the increased incidence is likely caused by changes in diet and lifestyle that accompany displacement from their homes, especially if they find themselves living in hotels or other shelters for extended periods of time. The studies examining diabetes in this fashion, however, are limited to the Fukushima Dai-ichi emergency event.

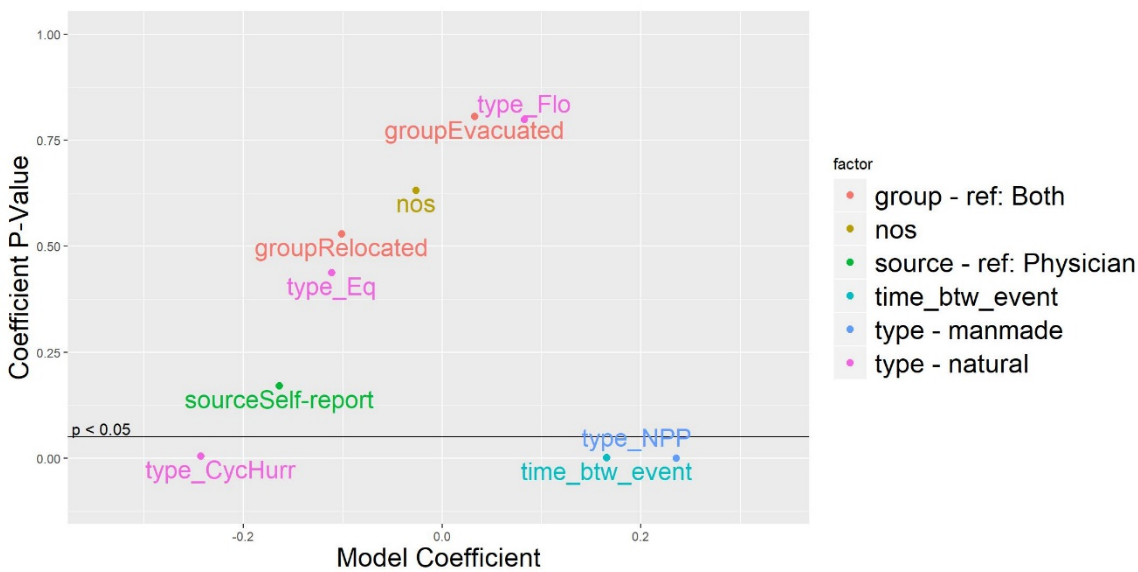

Figure 4-16 Meta-regression of Odds Ratio for Diabetes

Why hurricanes have a lower odds ratio is a somewhat more complicated question. Looking at prevalence in the nondisplaced populations, there is a significant increase associated with hurricanes and cyclones. Unlike earthquakes, hurricanes are often accompanied by up to 72 hours of warning, potentially giving people with diabetes time to take additional measures to prevent the need to evacuate. Despite this, at-risk populations with diabetes are not likely to evacuate given the opportunity, especially if they have other chronic conditions or mobility concerns (Behr, 2013). If these populations elected to stay, this choice would result in a lower fraction of people with diabetes evacuating. When calculating the odds ratio, this increased prevalence in the nondisplaced populations could disguise part or all of an increase in diabetes among the displaced population caused by evacuation. Alternatively, given that hurricanes are common hazards in some parts of the United States, it is possible that socioeconomic forces are the primary drivers behind nonevacuation of individuals with diabetes, or indeed of any population in the evacuation area, following hurricanes.

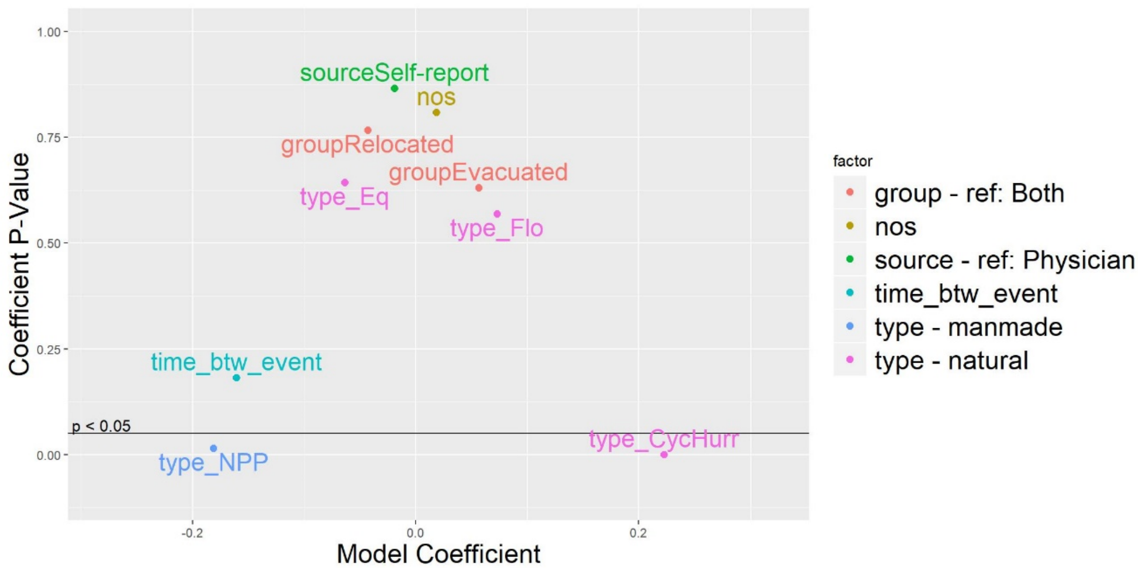

Figure 4-17 Meta-regression of Prevalence of Diabetes in Displaced Populations

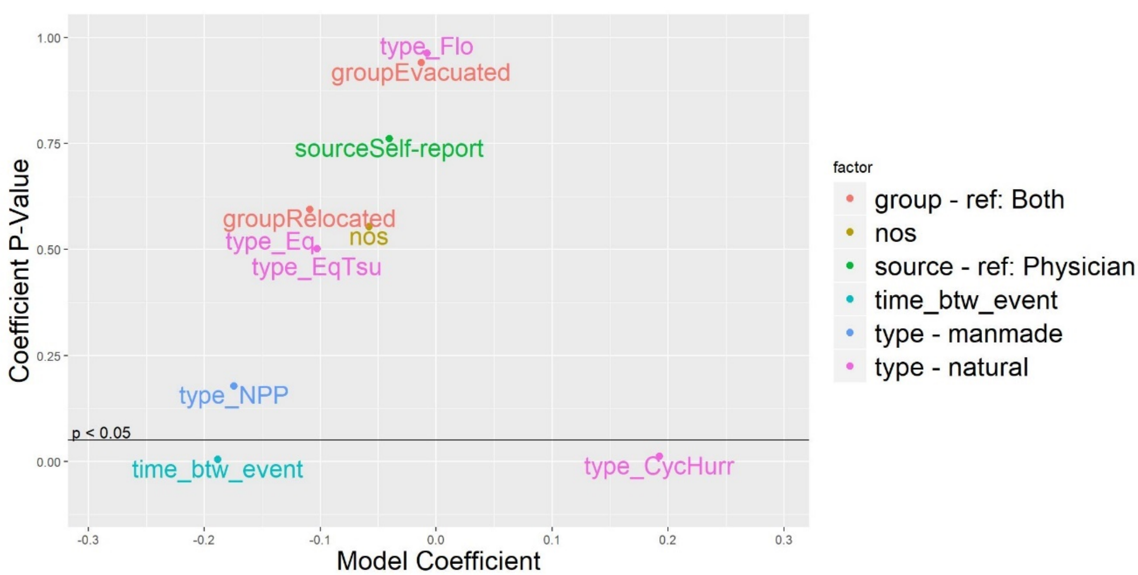

Figure 4-18 Meta-regression of Prevalence of Diabetes in Nondisplaced Populations

4.1.4 General Health Effects

General health effects cover a myriad of different effects that did not fit in other categories, including changes in blood pressure or incidence of gastrointestinal issues. Table 4-2 lists the specific health effects included in each paper.

Table 4-2 Specific General Health Effects Included in the Meta-analysis

Study	Specific Health Effect
Dirkzwager (2006a)	Worse general health
Ebner (2016)	Metabolic syndrome
Hashimoto (2017)	Incidence of metabolic syndrome
Hayashi (2017)	Chronic kidney disease
Lawrence (2019)	Injury
Milne (1977)	Still-active injuries
Ohira (2017)	Hypo-HDL cholesterolemia
Satoh (2016a)	Hypo-HDL cholesterolemia
Takahashi (2016)	Dyslipidemia
Tomio (2010)	Health status after disaster: somewhat worse or much worse
Yzermans (2005)	Reporting medically unexplained physical symptoms

The meta-analysis of this broad category found a significant increase in these effects among displaced populations, as shown Figure 4-19. A substantial difference is also visible in the prevalence of these health effects between the displaced populations and nondisplaced populations, as seen in Figure 4-20 and Figure 4-21, respectively.

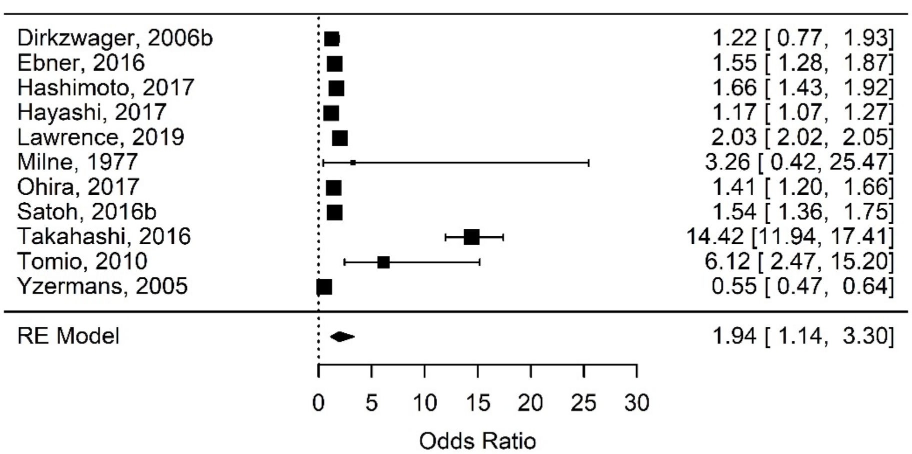

Figure 4-19 Meta-analysis of Odds Ratio for General Health Effects

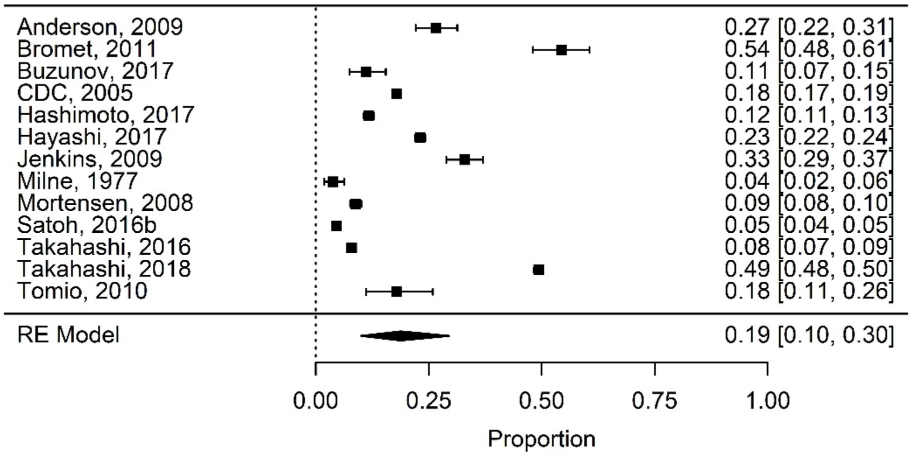

Figure 4-20 Prevalence of General Health Effects in Displaced Populations

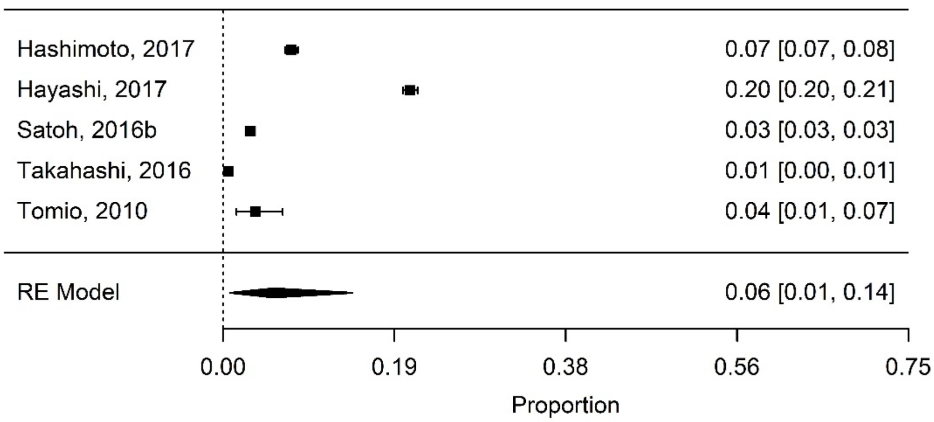

Figure 4-21 Prevalence of General Health Effects in Nondisplaced Populations

The causal relationship between evacuation and general health effects is difficult to determine, because of both the number of health effects captured in this category and evidence that suggests that people in poorer health are more likely to evacuate, if they are able. A 2017 study in New Jersey, for example, found that former stroke victims were more likely to evacuate for Hurricane Sandy than the general population (Kulkarni, 2017). Additionally, a 2006 study found that, besides evacuation, preexisting psychological conditions, coming from an immigrant background, financial loss, and injuries were all associated with reporting health difficulties, suggesting there may be a self-selection of people with general health problems into evacuated populations (Dirkzwager, 2006a). This category may also be more sensitive to control-related errors in studies that use nearby communities as control populations. A study in Texas found that a disproportionately large number of people with disabilities were located near potentially hazardous facilities (Chakraborty, 2019). Further, health is strongly associated with socioeconomic status, so areas with higher rates of poverty are likely to have higher rates of health issues while simultaneously having fewer resources to aid in evacuation or relocation (Adler, 1999). Comparing two different communities with different socioeconomic levels may therefore be a confounding factor.

Figure 4-22 shows the results of the meta-regression of the odds ratio data. This analysis found three significant factors: self-reported data, test-confirmed data, and earthquake and tsunami incidents. The meta-regression showed that studies that relied on evacuees to report general health effects saw a significantly higher rate of health effects relative to physician-diagnosed data. Interestingly, studies that relied on standardized tests given by research personnel showed a lower rate of effects relative to studies that used physician-diagnosed effects. Earthquake and tsunami incidents were related to higher odds ratios—that is, higher rates among displaced populations relative to nondisplaced populations—while other emergency event types did not show any effects. It is not clear why earthquakes and tsunamis alone are associated with higher odds ratios and other no-notice or short-notice emergencies are not. Studies of preparation for emergencies in nursing homes—important for events with significant notice such as hurricanes—showed that even with preparation, residents were still at high risk of morbidities. This may partially explain why a marked difference is not seen between notice and no-notice events (Blanchard, 2009).

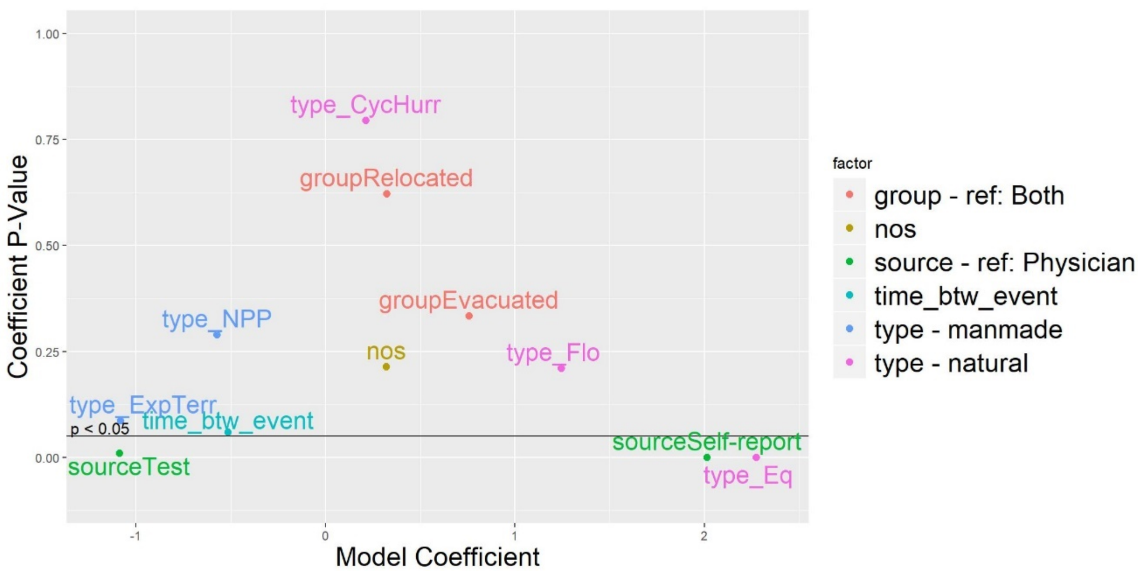

Figure 4-22 Meta-regression of Odds Ratio for General Health Effects

The meta-regression of the prevalence data (Figure 4-23 and Figure 4-24) does not add insight. The meta-regression found no significant factors affecting prevalence in displaced populations. In nondisplaced populations, the meta-regression found two significant factors: the study's NOS score and the time between the event and the data collection. Neither of these factors is shared with the odds ratio meta-regression in Figure 4-22, suggesting they are not large enough factors to influence the relationship between the prevalence of general health effects observed in the displaced and nondisplaced groups. Understanding why the time between the emergency event and measurement matters for this group is difficult, as most studies examined populations at only one point in time. A handful of studies did examine the effects of time but provide somewhat contradictory results. A longitudinal study of medically unexplained physical symptoms found an increasing prevalence with time in relocated victims of a fireworks accident in the Netherlands but no trend in the nonrelocated victims (Yzermans, 2005). Despite this, the study found a negative relationship between time and effect in the evacuated population—albeit not statistically significant—and a positive relationship in the nondisplaced population. A possible explanation for this effect of time after the event is the wide variety of health effects included in the general health effects category. A study of health effects examining only the evacuees of one village in Fukushima similarly saw an increasing risk for some health effects with time following the evacuation but not for other health effects (Ebner, 2016). In this study, hypertension and chronic kidney disease both increased following evacuation, but hyperuricemia and obesity both dropped from 2012 to 2013. As a result, care needs to be taken in interpreting these results. While there is an increase in the general health complaints among displaced populations, these results cannot point to specific health concerns that evacuees might experience.

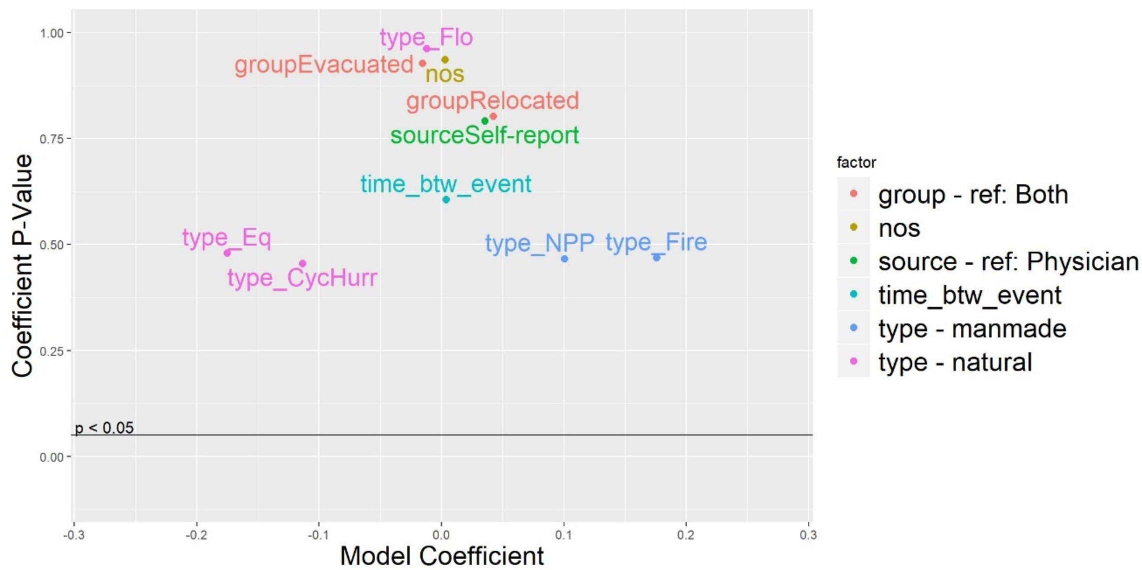

Figure 4-23 Meta-regression of Prevalence of General Health Effects in Displaced Populations

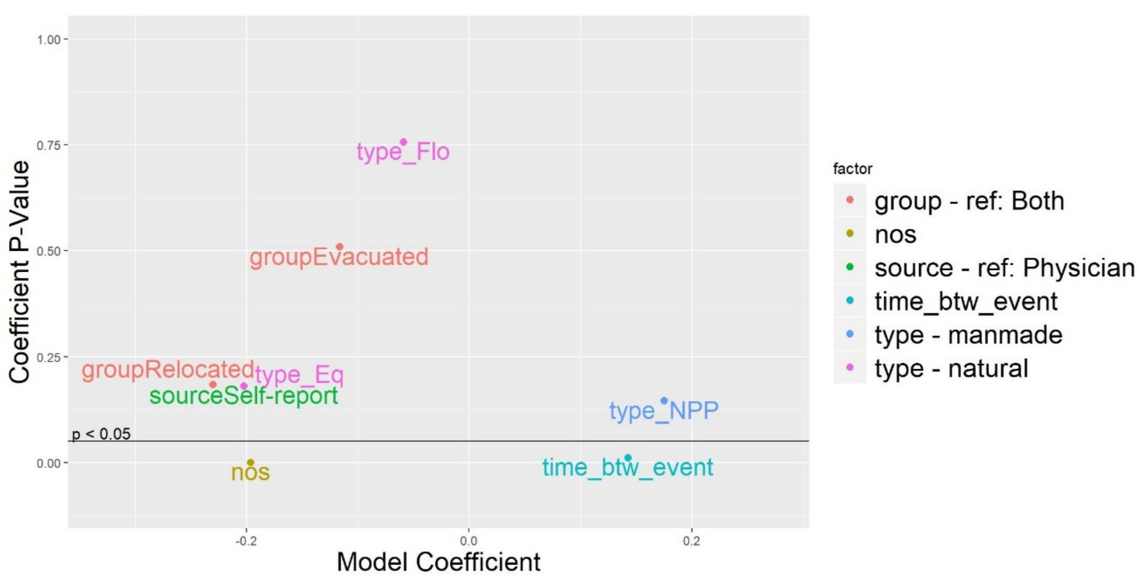

Figure 4-24 Meta-regression of Prevalence of General Health Effects in Nondisplaced Populations

4.1.5 Healthcare Accessibility Issues

The category of healthcare accessibility issues captures all issues related to the lack of availability of healthcare following an emergency event, including disruption of access to primary care, emergency care, and pharmacy care. The meta-analysis of odds ratio data (Figure 4-25) did not find a significant relationship between healthcare accessibility problems and evacuation or relocation. Despite this, the effect size found in the analysis is quite large, with an odds ratio greater than 2.0. Additionally, three of the four studies examining healthcare accessibility did find statistically significant odds ratios. This finding does not discount the fact that many evacuations have resulted in healthcare accessibility problems for evacuees (several studies reviewed reported such problems), but this finding does show there is not a generalizable relationship between evacuation or relocation and healthcare accessibility issues relative to the nondisplaced populations for all emergency events. Additionally, as emergency managers have a general awareness that healthcare accessibility is a problem following displacement, it can be anticipated that some emergency events would not show an issue in accessibility because of the mitigation efforts by emergency managers (HHS, 2016). Figure 4-27 shows that, on average, 10 percent of nondisplaced populations experienced healthcare accessibility problems. Interestingly, despite the lack of significant association, the prevalence of healthcare accessibility problems among all displaced populations included in the analysis is much higher, at 19 percent, as shown in Figure 4-26.

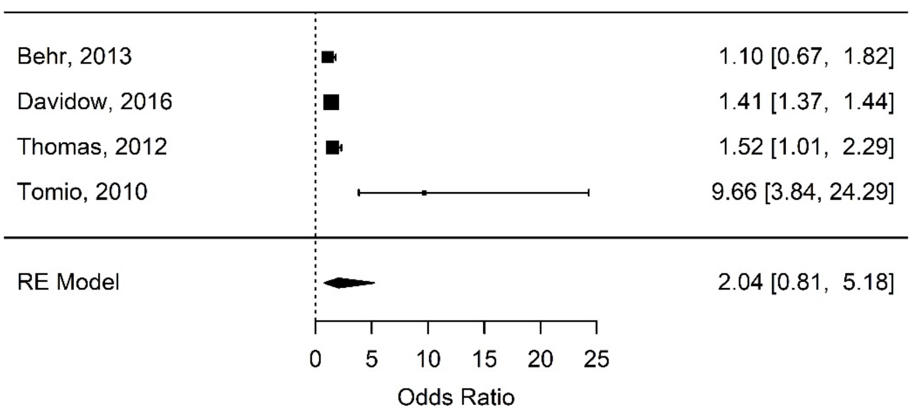

Figure 4-25 Meta-analysis of Odds Ratio for Healthcare Accessibility Issues

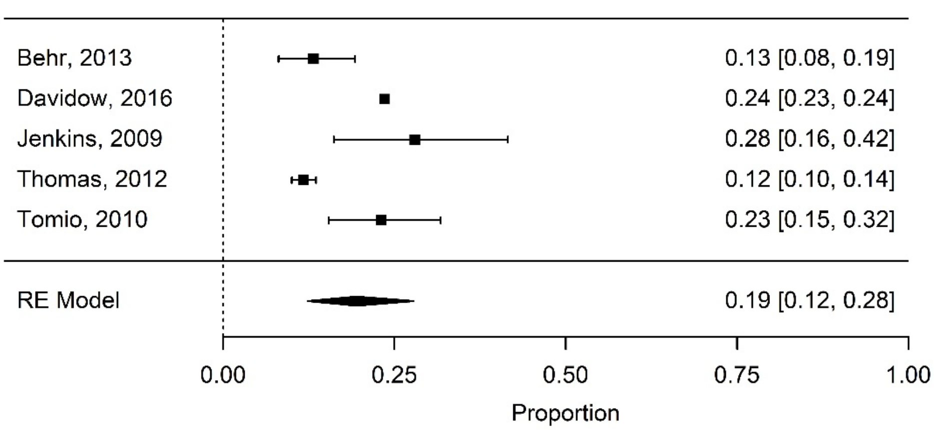

Figure 4-26 Prevalence of Healthcare Accessibility Issues in Displaced Populations

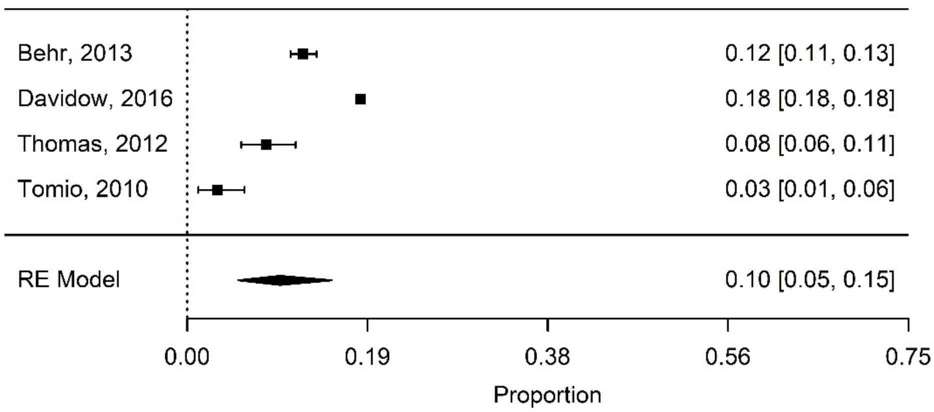

Figure 4-27 Prevalence of Healthcare Accessibility Issues in Nondisplaced Populations

The meta-regression of the odds ratio data (Figure 4-28) identifies two emergency event types with a significant effect on the odds ratio. Floods were associated with higher odds ratios, while hurricanes and cyclones were associated with lower odds ratios. As hurricanes and cyclones are associated with periods of up to several days of warning, it is not surprising that healthcare accessibility issues are not as acute because responders have time to set up the infrastructure needed to receive evacuated populations. For a typical hurricane season, the Federal Emergency Management Agency (FEMA) monitors hurricane tracks out for days ahead of time (FEMA, 2020). Hurricane tracks increase in accuracy as the hurricane approaches land. These hurricane tracks are used to inform state and local planners to prepare for the hurricane's arrival by setting up shelters, evacuating high-risk areas, and performing other emergency preparations. No-notice or short-notice events provide responders with less time to prepare.

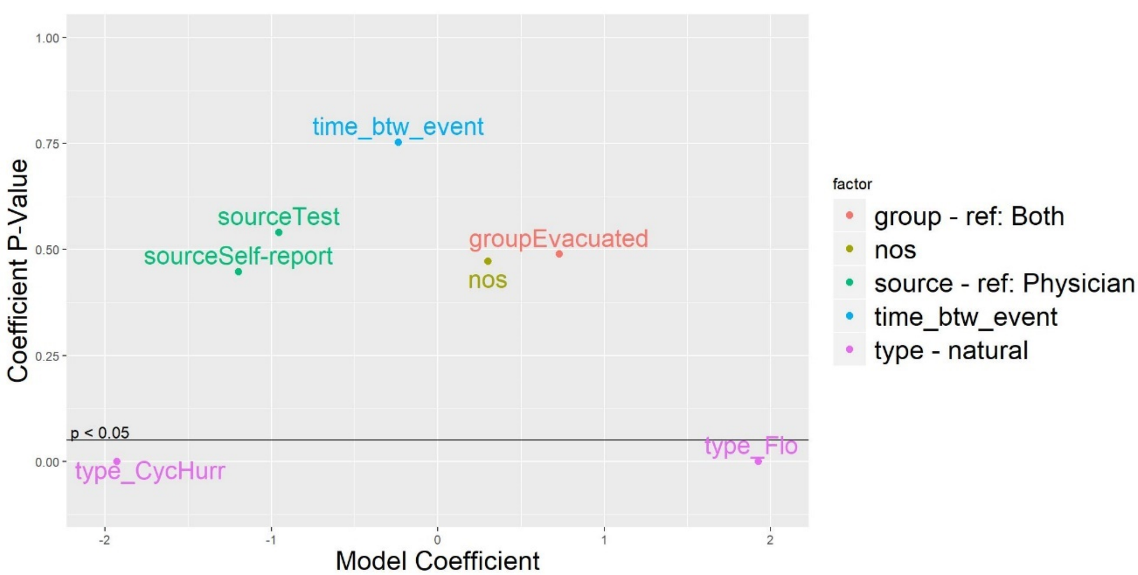

Figure 4-28 Meta-regression of Odds Ratio for Healthcare Accessibility

Figure 4-29 shows that no individual variable is significant in determining the prevalence for displaced populations, but Figure 4-30 shows that for nondisplaced populations, a lower prevalence of healthcare accessibility is associated with floods and a higher prevalence of healthcare accessibility problems is associated with hurricanes. Several studies have shown that proper planning mitigates healthcare accessibility problems, while poor planning can cause undue harm (Baker, 2018; Downey, 2013a; Verni, 2012). Healthcare facilities in emergency event areas should be prepared to receive patients even after the event occurs or be prepared to notify patients of a different place to receive care (Downey, 2013b). Otherwise, evacuees will likely see increases in negative health outcomes, including deteriorating conditions or death, after evacuation. In one study, evacuees who experienced an interruption in medication were much more likely to have deteriorated in health in the month after the emergency event (odds ratio of 4.5 compared to those who did not have interrupted medication) (Tomio, 2010). For populations with more substantial medical needs, such as populations who are functionally impaired and highly dependent on medical staff for everything from eating to personal hygiene, evacuation and interruption in healthcare led to an 8-percent higher rate of hospitalization (Thomas, 2012).

Figure 4-29 Meta-regression of Prevalence of Healthcare Accessibility Issues for Displaced Populations

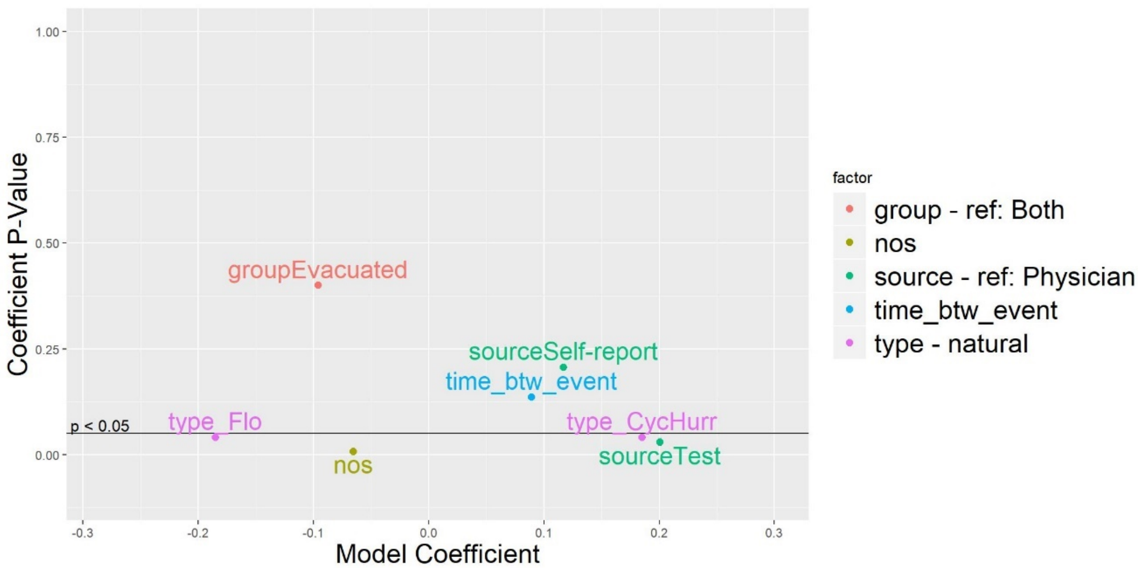

Figure 4-30 Meta-regression of Prevalence of Healthcare Accessibility Issues for Nondisplaced Populations

4.1.6 Heart Disease

Heart disease is a class of several heart conditions, including coronary artery disease, heart valve dysfunctions, and congenital heart defects. The analysis of heart disease included studies that examined all cardiovascular illness, key risk factors such as hypertension, and fatalities caused by heart attacks. The meta-analysis on reports of heart disease (Figure 4-31) found an odds ratio of 1.07, indicating a small increase in heart disease among displaced populations. Several individual studies contributed odds ratio effect sizes less than 1.0, indicating a greater proportion of nondisplaced persons reporting heart disease than the displaced population in those individual studies. One study with a high individual effect size could be an outlier in this analysis (i.e., Lawrence, 2019). Given the range in effect sizes reported in the literature, the meta-analysis did not show a significant increase or decrease in heart disease resulting from evacuation. The prevalence of heart disease was high in both displaced and nondisplaced populations, with estimated values equal to 0.43 and 0.47, as shown in Figure 4-32 and Figure 4-33, respectively.

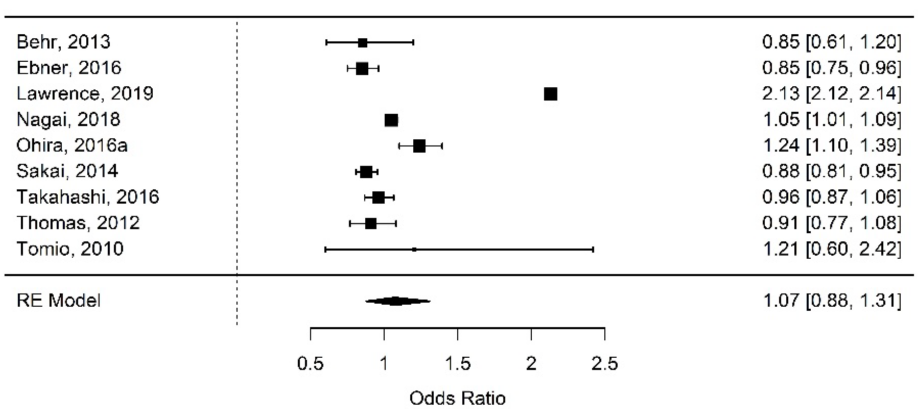

Figure 4-31 Meta-analysis of Odds Ratio for Heart Disease

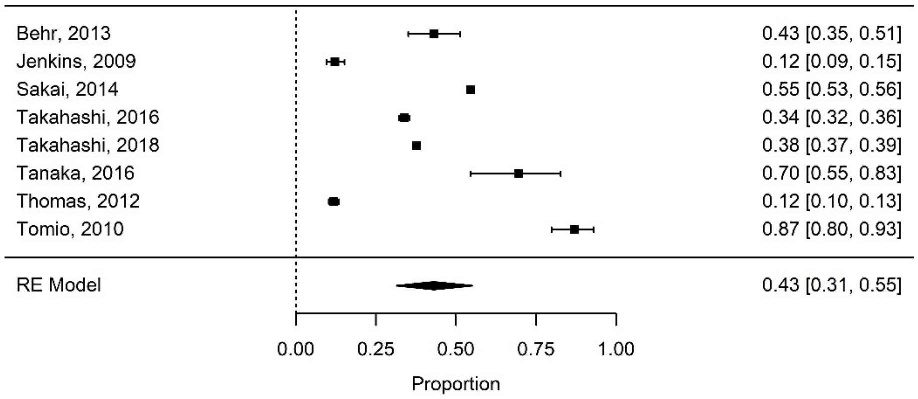

Figure 4-32 Prevalence of Heart Disease in Displaced Populations

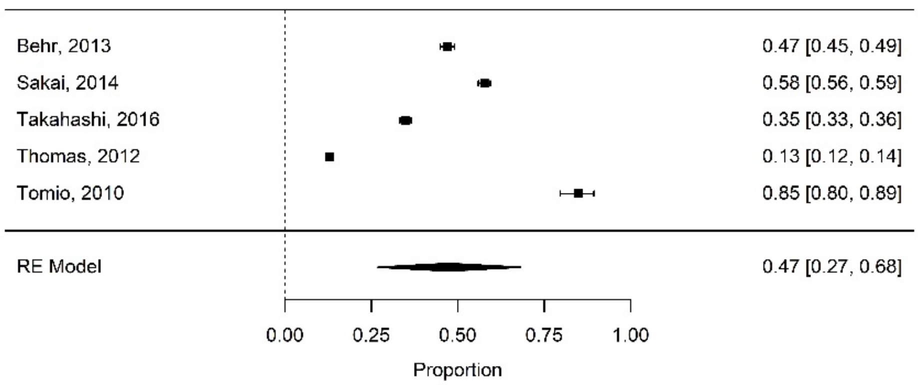

Figure 4-33 Prevalence of Heart Disease in Nondisplaced Populations

The meta-regression of odds ratios identified no individual variable that had a statistically significant association with the odds ratio, as shown in Figure 4-34. The meta-regression of the prevalence of heart disease in displaced populations (Figure 4-35) found several significant variables, including wildfires, hurricanes and cyclones, floods, and whether the population was evacuated. Most interesting, this analysis found that evacuated populations, but not relocated populations, were at higher risk of heart disease. It is not clear why there is a higher risk with evacuated population, and no papers were identified that explored this difference. This effect is not due to time between the event and data collection alone, as that variable was found to have a separate effect, though it was not statistically significant. Like many of the other outcomes, this analysis found that, for displaced populations, floods were associated with greater prevalence of heart disease, while hurricanes and cyclones were associated with lower prevalence relative to the average across all emergency events. This effect disappears and actually reverses (although not statistically significant) in the odds ratio meta-regression (Figure 4-34). Wildfire event studies are an interesting addition and were found to be associated with lower prevalence effect sizes than hurricane studies. While some communities may have advance warning of approaching wildfires, it is not clear if this is the cause of lower prevalence. Another possibility is that because wildfires typically occur in different geographic areas than hurricanes, there may be larger socioeconomic, demographic, or cultural reasons for the lower overall prevalence.

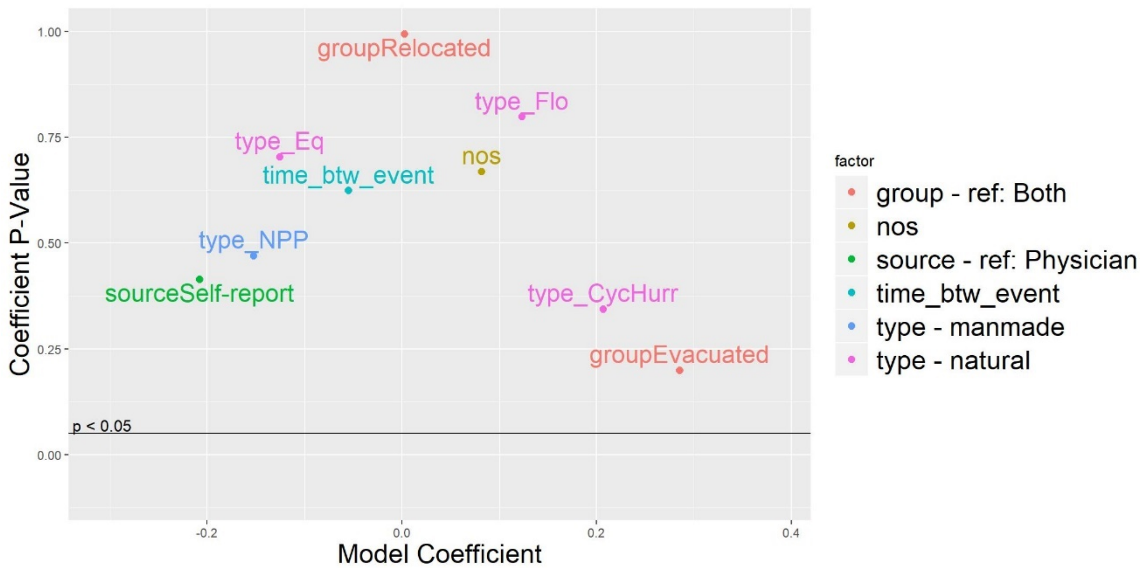

Figure 4-34 Meta-regression of Odds Ratio for Heart Disease

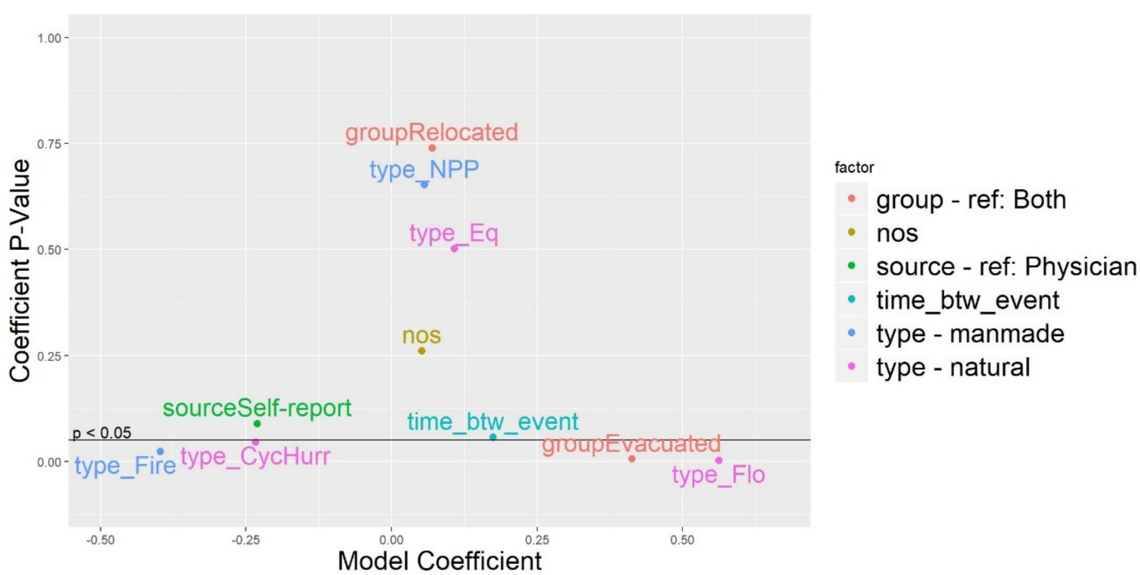

Figure 4-35 Meta-regression of Prevalence of Heart Disease in Displaced Populations

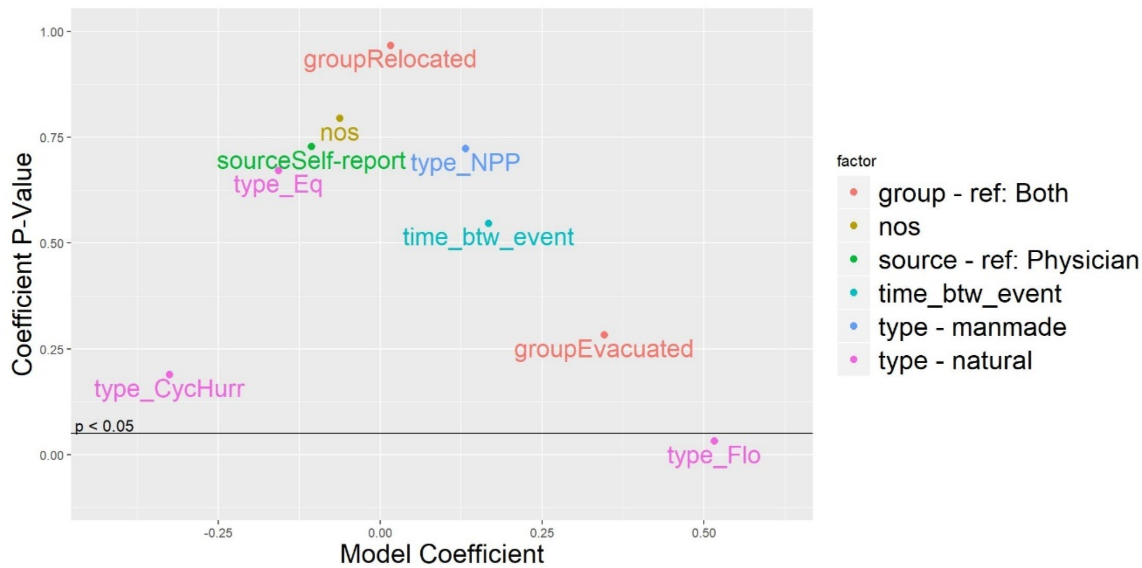

Figure 4-36 Meta-regression of Prevalence of Heart Disease in Nondisplaced Populations

4.1.7 Mortality

Mortality included all evacuation-related deaths not already captured by other health effects (e.g., not heart attacks included in the heart disease analysis above). While deaths from the hazard itself were excluded (e.g., building collapse deaths from an earthquake), transportation deaths during evacuation were included because they would not have occurred without the evacuation. Mortality in this section included deaths during the evacuation of hospitals, elderly care or nursing facilities, and admittees at a hospital that serviced both displaced and nondisplaced populations near the Fukushima nuclear power plant. No specific data on suicide were identified, so this category does not include suicide mortality. The meta-analysis, shown in Figure 4-37, found an odds ratio of 1.76, which is a significant increase in mortality in displaced populations compared to those who did not evacuate or relocate. While there was a significant relationship and a relatively large odds ratio for mortality, the overall prevalence in both displaced and nondisplaced groups is small, as demonstrated in Figure 4-38 and Figure 4-39, respectively. Even so, any increase in mortality among displaced populations should be taken very seriously.

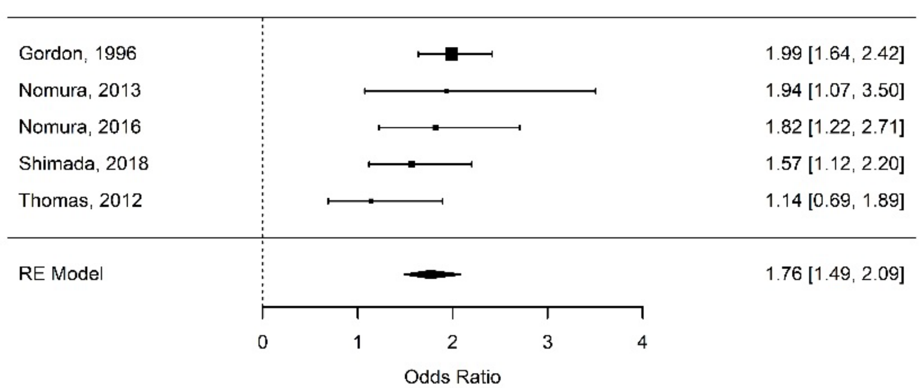

Figure 4-37 Meta-analysis of Odds Ratio for Mortality

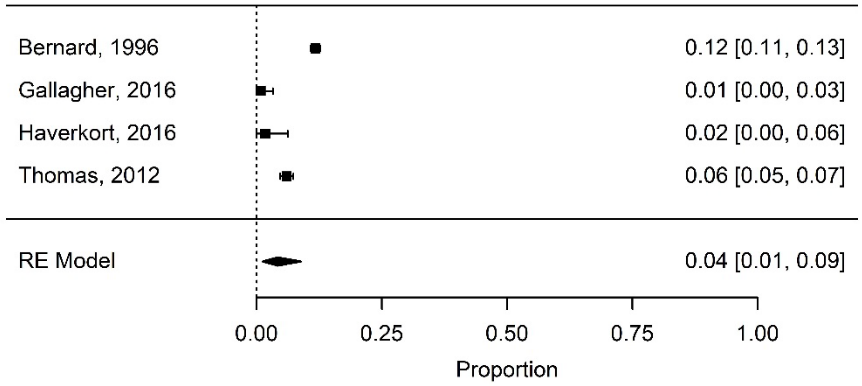

Figure 4-38 Prevalence of Mortality in Displaced Populations

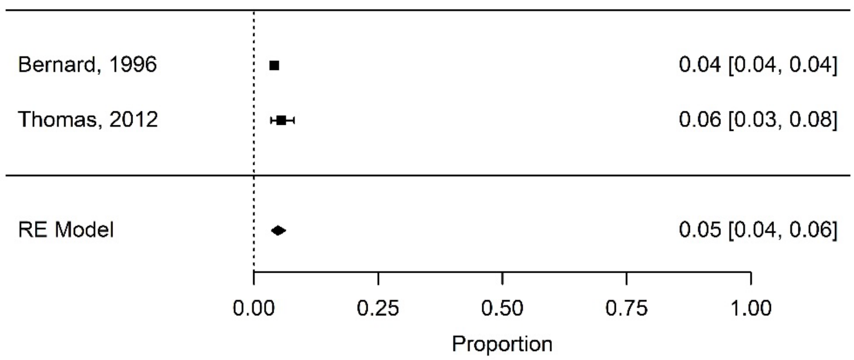

Figure 4-39 Prevalence of Mortality in Nondisplaced Populations

Figure 4-40 shows that a meta-regression of the odds ratio data found no significant factors associated with mortality. However, a meta-regression on prevalence of mortality in displaced populations (Figure 4-41) revealed several significant factors. Although the effects were small, this analysis found that evacuation was associated with slightly lower mortality, while relocation was associated with slightly higher mortality. It is not immediately apparent why this would be true, since evacuation presumably involves transportation twice—once out of evacuated area and one back into it—and two opportunities for disruption of continuity of care for hospitalized individuals. Some of this apparent effect may be explained by nursing home residents or hospitalized patients returning to facilities where workers are familiar with their particular needs—essentially a return to their normal continuity of care (Nomura, 2016). Additionally, studies of psychological distress (Section 4.1.9) have noted increased psychological distress caused by loss of familiar environments or social support networks (Horikoshi, 2017). Some studies have suggested that unfamiliar environments may be particularly stressful to the elderly because of loss of autonomy that may accompany displacement, though data were not available to assess this finding with certainty (Castle, 2001). Similarly, it is possible that the increase in psychological distress is having a negative effect on relocated populations and that the return to normalcy is beneficial for returning evacuated populations. This return to normalcy results in the ability of evacuees to return to their regular habits and reestablish social connections, reducing isolation (Castle, 2001; Cao 2015). Most deaths following evacuation occurred within 100 days of evacuation (Shimada, 2018; Thomas, 2012), though other studies showed continued risks for more than 250 days following evacuation (Nomura, 2016; Nomura, 2013). This long-term increased risk of death means that at least a portion of the risk is not due to disruption of continuity of care. One paper examining these effects hypothesized that the psychological distress associated with uncertainty and being away from home may be the cause (Tanaka, 2015). Even after return to their homes, however, mortality risks remain elevated among nursing home patients for as long as 6 months compared to pre-evacuation levels (Willoughby, 2017).

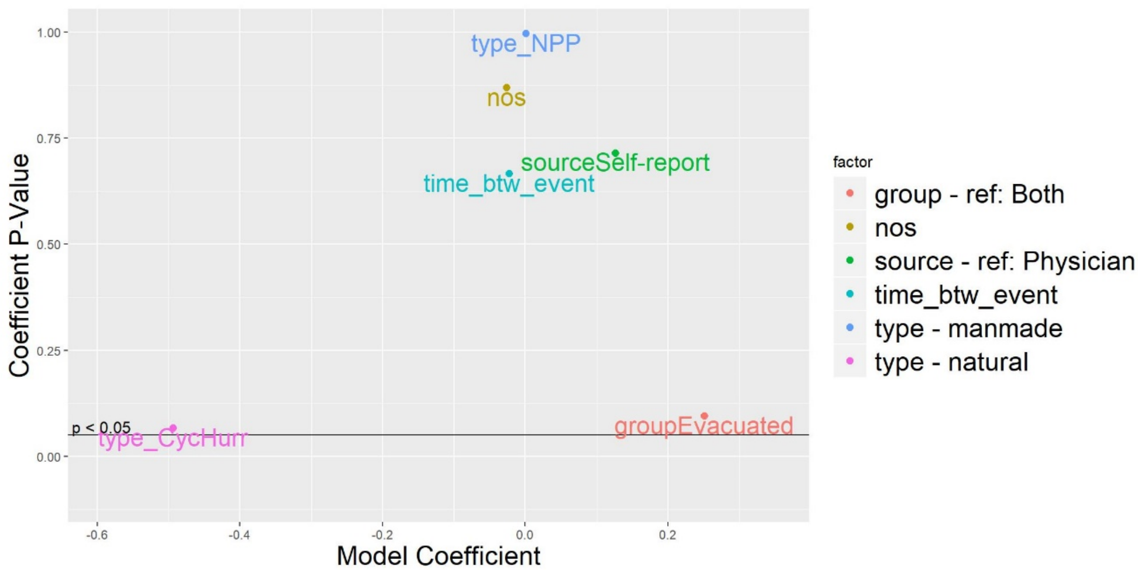

Figure 4-40 Meta-regression of Odds Ratio for Mortality

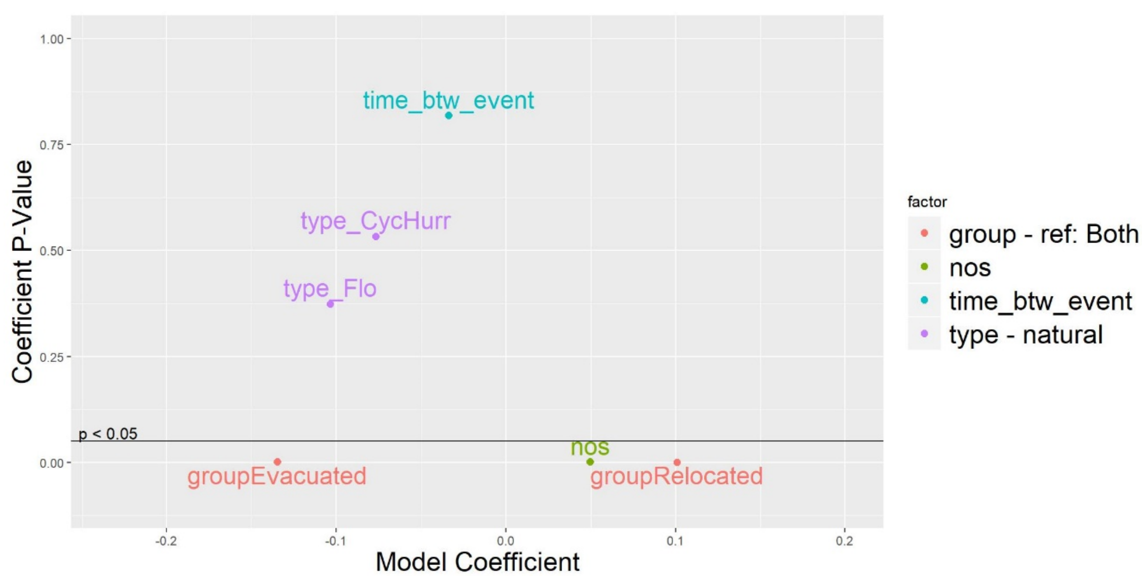

Figure 4-41 Meta-regression of Prevalence of Mortality in Displaced Populations[1]

[1] Insufficient data was available to perform a meta-regression for nondisplaced populations.

4.1.8 Posttraumatic Stress Disorder

PTSD is a psychiatric disorder that results from a sentinel event or events strongly encoded in emotional memory, typically an extremely traumatic event such as experiencing a major disaster (Bremner, 2006). Symptoms of PTSD typically include flashbacks or bad dreams, avoidance symptoms, feelings of being "on edge" or difficulty in sleeping, and mood disruption (NIH, 2019). Sufferers of PTSD are also at higher risk of experiencing anxiety, psychological distress, substance abuse disorders, and depression (Bremner, 2006). The kind of memory formation seen in PTSD is most evident when you ask the average American where they were and what they were doing when terrorists attacked the United States on September 11, 2001. Traumatic events are hard to forget or normalize—they become a continuing and repeated source of anxiety, even if not all criteria for PTSD exist. In such a case, it is important to remember that subthreshold mental illness—that is, a mental illness that does not meet the specific diagnostic criteria—is not the same as no mental illness. Cases of subthreshold PTSD are likely captured in the anxiety, depression, and psychological distress categories. The meta-analysis found a significant relationship between PTSD and evacuation or relocation, with an overall average odds ratio of 1.73, as shown in Figure 4-42. This finding is reflected in a large disparity in the overall prevalence of PTSD in the displaced and nondisplaced populations, shown in Figure 4-43 and Figure 4-44, respectively. PTSD is nearly inevitable among a population following an emergency, regardless of whether it was manmade or natural or whether there was an evacuation event (Neria, 2008). Although symptoms of PTSD vary, PTSD among Fukushima evacuees often manifested as traumatic memories of the plant explosion and evacuation and hyperarousal symptoms such as irritability, panic, anxiety, and sleeping problems (Hasegawa, 2016).

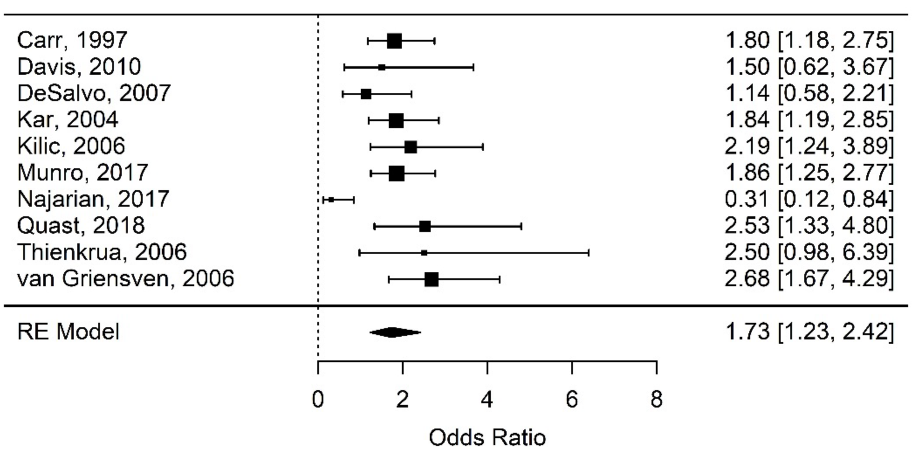

Figure 4-42 Meta-analysis of Odds Ratio for PTSD

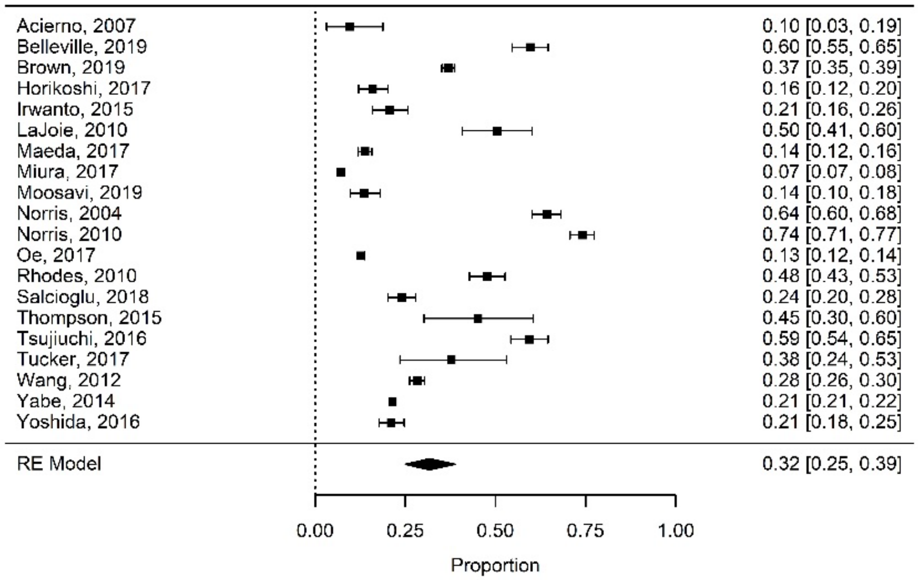

Figure 4-43 Prevalence of PTSD in Displaced Populations

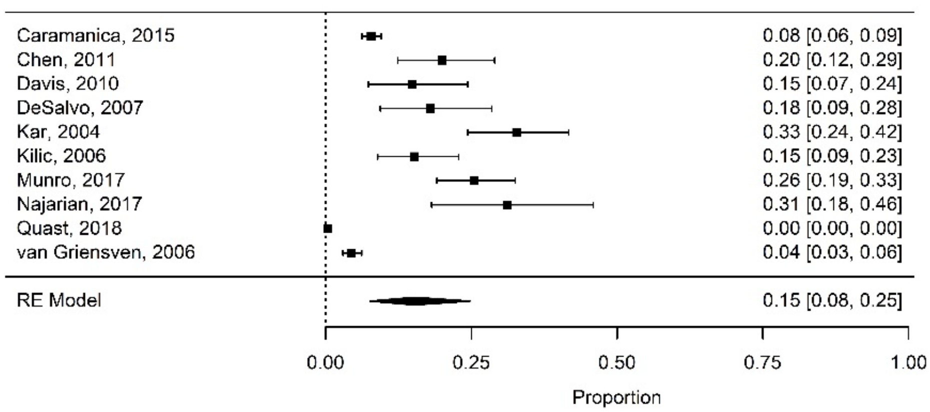

Figure 4-44 Prevalence of PTSD in Nondisplaced Populations

The meta-regression of odds ratio data for PTSD identified only one significant variable: the time between the emergency event and the data collection (Figure 4-45). This finding was expected, as PTSD by definition typically takes some time to onset and then may self-resolve or be resolved with support from therapists or other medical professionals. For displaced populations, the meta-regression found that both relocation and flood events were associated with higher prevalence of PTSD (Figure 4-46). Nuclear power plant accidents were not significant at the 0.05 level of significance but did seem to be associated with lower rates of PTSD among displaced populations compared to other accident types. For nondisplaced populations, the only significant variable was whether the data were collected using a standardized test rather than physician-diagnosed PTSD (Figure 4-47). In essence, PTSD is the inability to emotionally forget a traumatic event or weave the event into a life story that one can live with. Being displaced may make it harder to normalize an event and may hinder working through what happened.

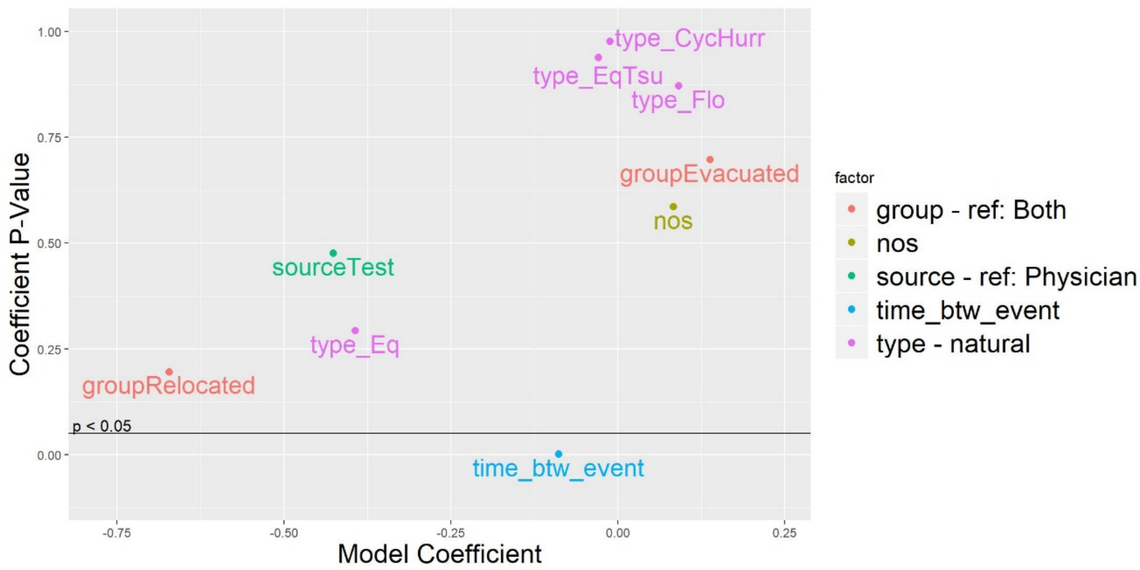

Figure 4-45 Meta-regression of Odds Ratio for PTSD

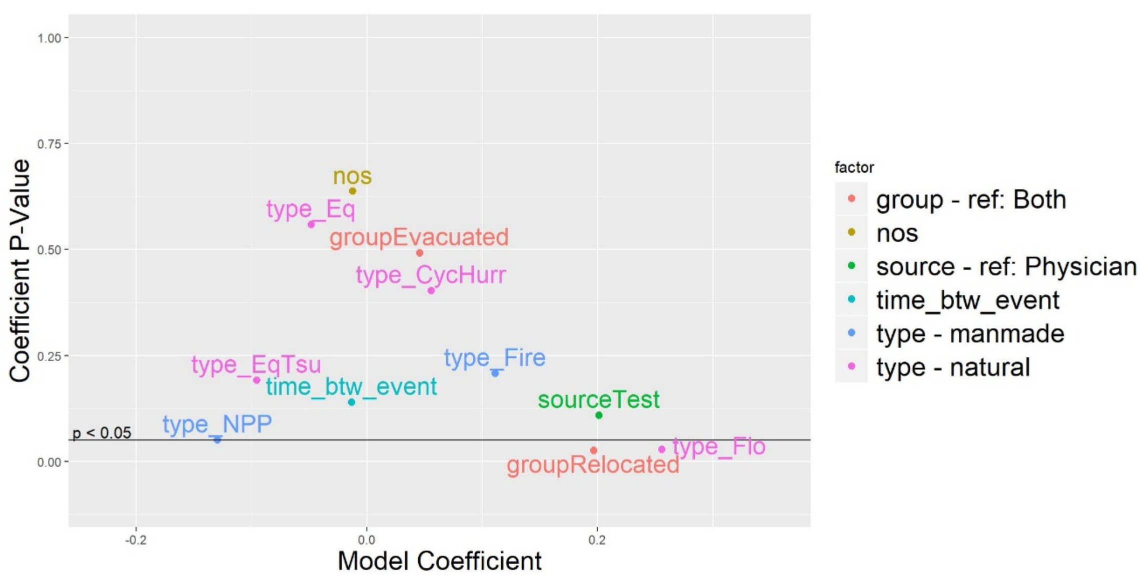

Figure 4-46 Meta-regression of Prevalence for PTSD in Displaced Populations

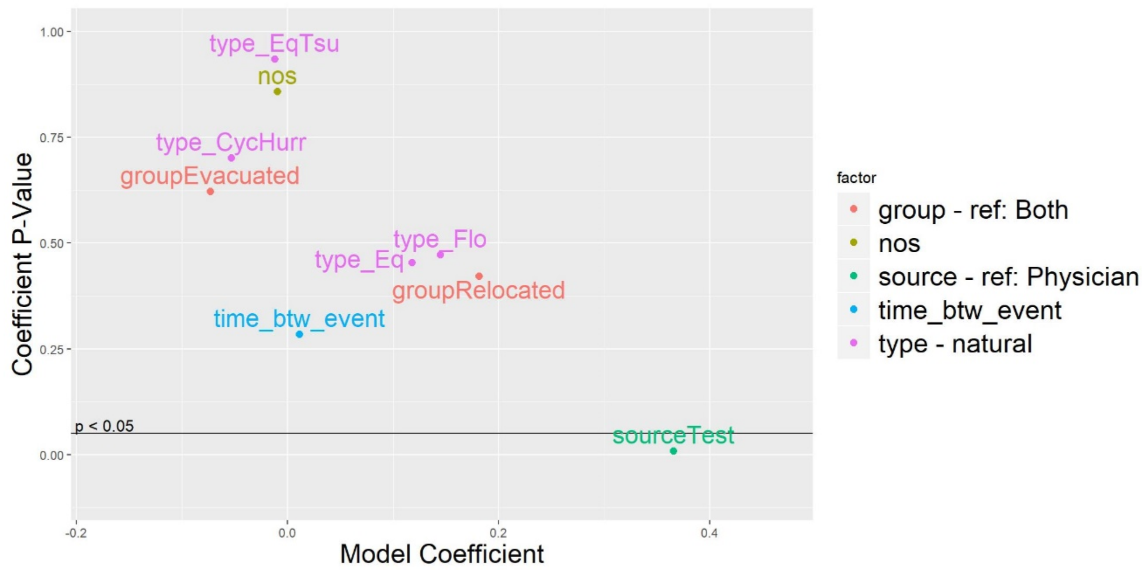

Figure 4-47 Meta-regression of Prevalence for PTSD in Nondisplaced Populations

4.1.9 Psychological Distress

Psychological distress is a broad effect that captures many aspects of mental anguish, including symptoms of anxiety or depression that do not necessarily rise to the level of an independent diagnosis. Other aspects of psychological distress include feelings of worthlessness, nervousness, restlessness or being fidgety, and fatigue without obvious reason (Andrews, 2001). The meta-analysis of the odds ratio data for psychological distress (Figure 4-48) found a statistically significant relationship between evacuation or relocation and an increase in psychological distress. The overall average odds ratio, 1.68, is one of the highest found during this analysis, suggesting that psychological distress is one of the greatest effects caused by evacuation or relocation. Unsurprisingly, psychological distress is prevalent among all emergency event survivors, including both displaced populations and nondisplaced populations, as shown in Figure 4-49 and Figure 4-50, respectively.

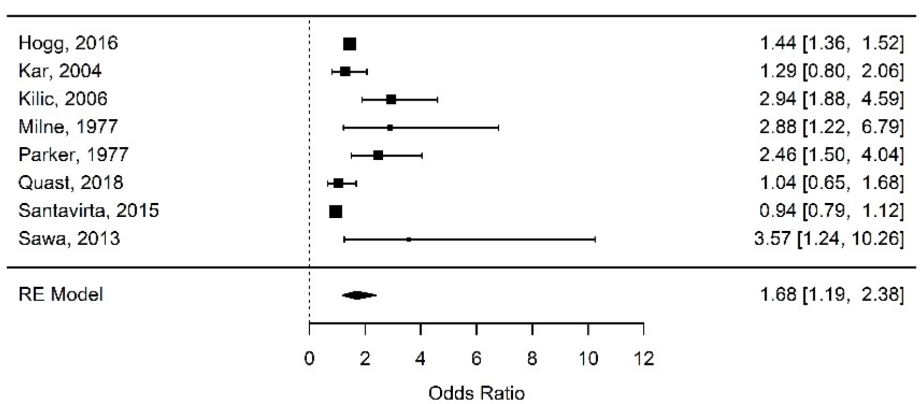

Figure 4-48 Meta-analysis of Odds Ratio for Psychological Distress

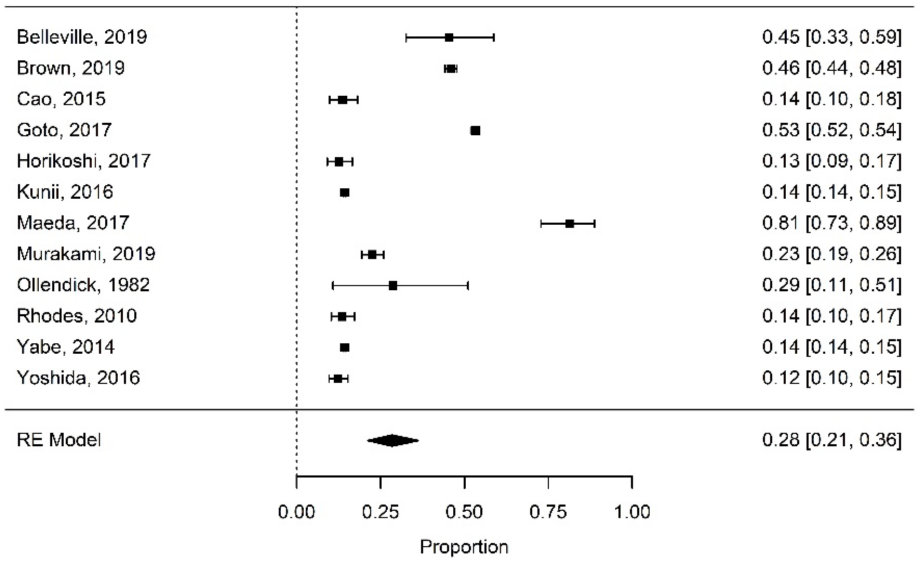

Figure 4-49 Prevalence of Psychological Distress in Displaced Populations

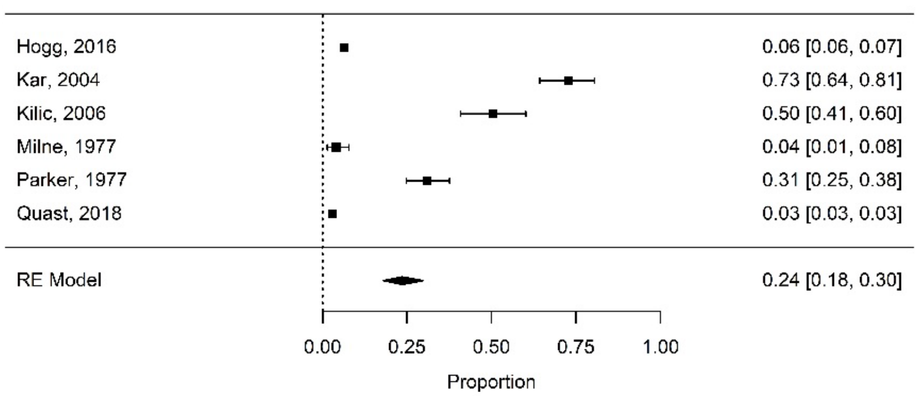

Figure 4-50 Prevalence of Psychological Distress in Nondisplaced Populations

The meta-regression of the odds ratio data (Figure 4-51) found that NOS score and wildfires were significant variables. Papers with higher NOS scores were found to be associated with lower odds ratios, suggesting that the more robust a study's methodology, the more likely they are to find lower rates of psychological distress. NOS scores of the included papers ranged from 2 to 7, with a bimodal distribution centered around 4 (six papers) and 6 (seven papers). However, the prevalence meta-regressions (Figure 4-52 and Figure 4-53) identified measurement method as a significant factor for prevalence among displaced populations and nondisplaced populations. Compared to physician-diagnosed psychological distress, both self-reported data and data collected using a standardized test, such as the K6, were associated with higher prevalence. None of these findings negate the clear relationship between displacement and psychological distress, but they do emphasize the need to take extra care not to overestimate the expected effect size.

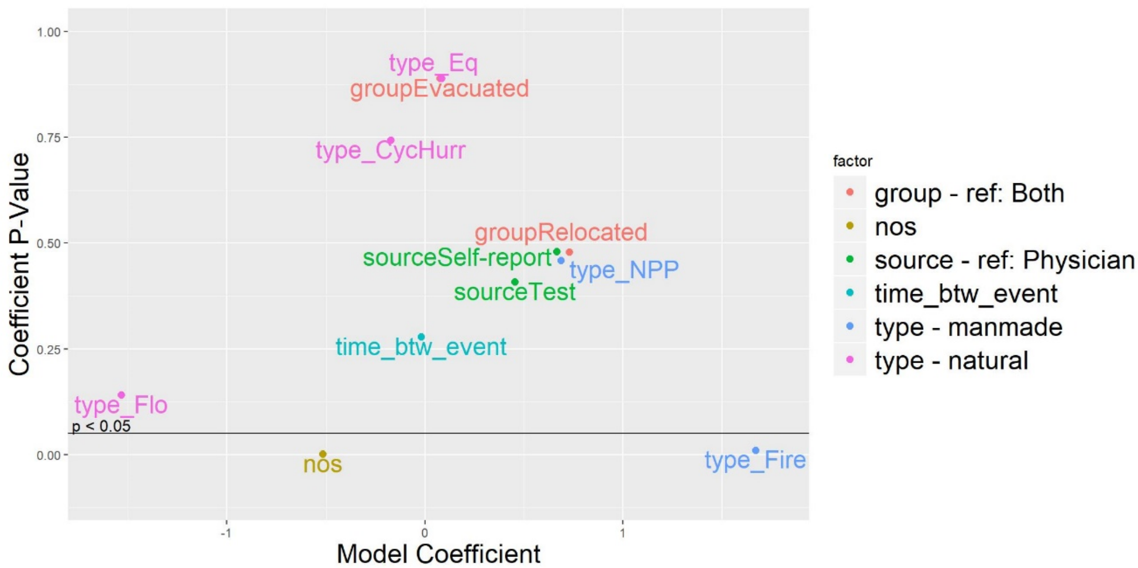

Figure 4-51 Meta-regression of Odds Ratio for Psychological Distress

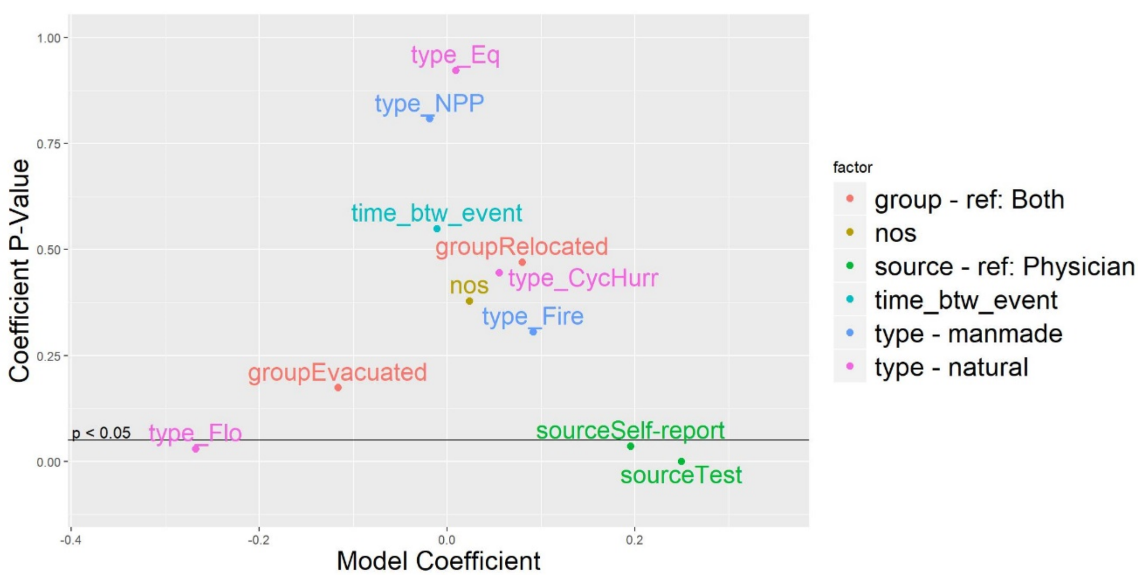

Figure 4-52 Meta-regression of Prevalence of Psychological Distress in Displaced Populations

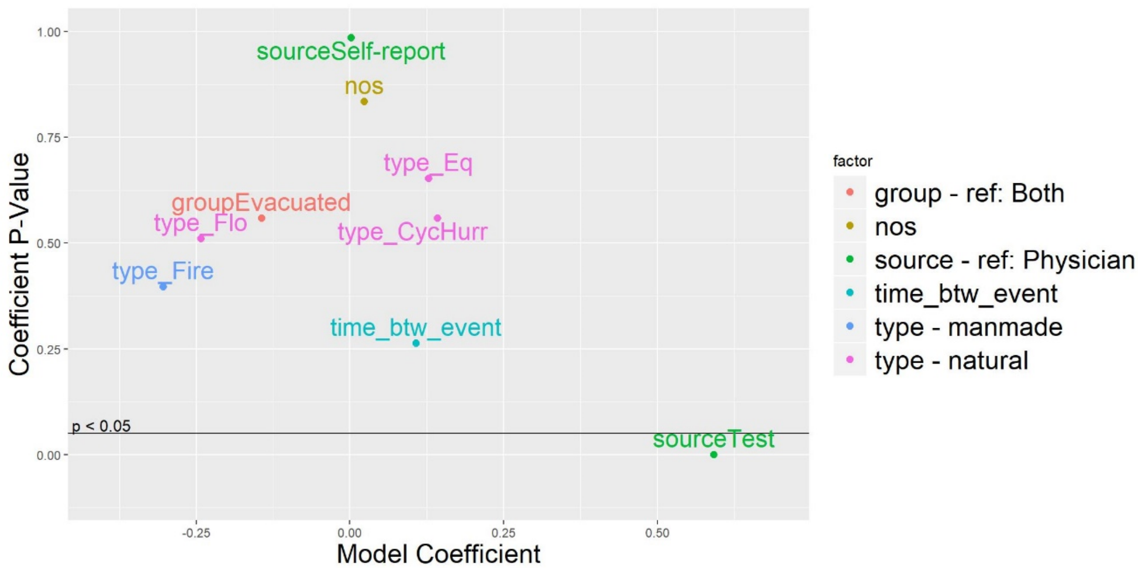

Figure 4-53 Meta-regression of Prevalence of Psychological Distress in Nondisplaced Populations

It is noteworthy that no emergency event type was associated with higher or lower psychological distress, indicating that noticed events or hazard-specific fears, such as radiophobia, are not major drivers of psychological distress. Instead, a survey among U.S. citizens found that fears of death, injury, and property loss were reliable predictors for psychological distress following emergency events, regardless of their type (Briere, 2000; Brooks, 2016; Kunii, 2016). Nevertheless, one study found that psychological distress was associated with the radiation levels in the environment in the years following the Fukushima disaster (Kunii, 2016). Although that study found a correlation ($r = 0.768$) between the presence of psychological distress of evacuees (K6 score >13) and average environmental contamination in the prefectures from which they evacuated, the study did not control for any other potential variables, such as suddenness of evacuation, severity of the earthquake or tsunami damage, or proximity to the plant.

Also, several populations are at particular risk for psychological distress, including children. Children are particularly at risk of psychological problems if permanently relocated (Pfefferbaum, 2017; Pfefferbaum, 2016). General responsiveness within the community and help from outside the community may decrease the secondary trauma of feeling as though such populations are not cared for. In communities with high cohesion, displacement may disrupt the otherwise beneficial connectedness within the community.

4.1.10 Respiratory Problems

The respiratory problems analysis included all illnesses of the lung, including acute bronchitis, infectious respiratory disease, and pneumonia, among others, except lung cancer. This outcome does not include the Coronavirus Disease 2019 (COVID-19), as all papers analyzed were published in 2019 or earlier. The meta-analysis of respiratory problems (Figure 4-54) found an odds ratio of 1.48, suggesting an increase in respiratory problems among displaced populations relative to nondisplaced populations. This odds ratio—although not found to be statistically significant—was less than 1.0 in only one of the studies in the literature reviewed. However, the identified papers had large within-paper variability, and some disparity becomes apparent when prevalence in displaced populations is analyzed separately, as shown in Figure 4-55. If an effect does exist, the hazard or displacement could cause respiratory problems in several potential ways. Wildfires and hazardous materials incidents may release particulate and harmful matter into the air in the short term, and these particulates may cover evacuation corridors or extend beyond evacuation zones into receiving communities. Additionally, overcrowding of displaced families in shelters, hotels, or other facilities may lead to the spread of infectious disease.

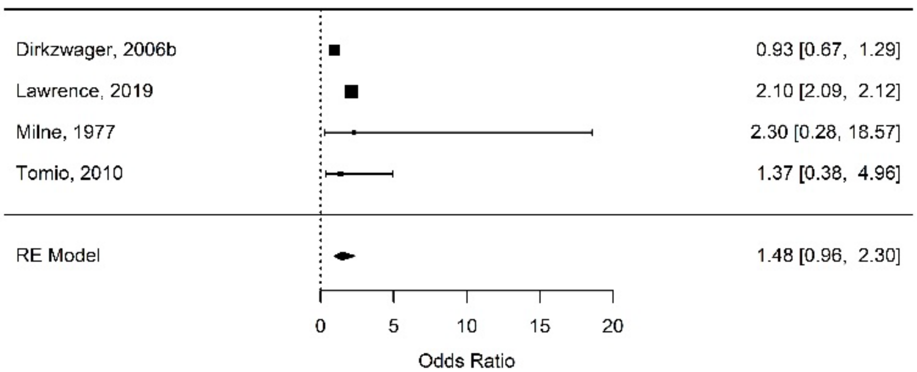

Figure 4-54 Meta-analysis of Odds Ratio for Respiratory Problems

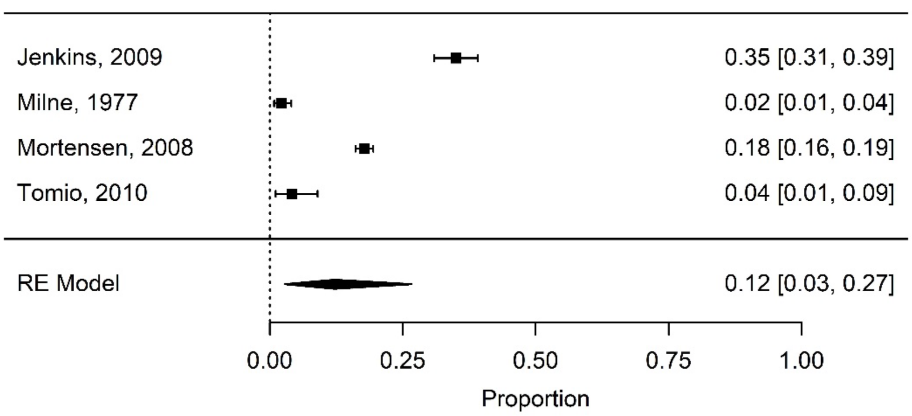

Figure 4-55 Prevalence of Respiratory Problems in Displaced Populations

The meta-regression of odds ratio data (Figure 4-56) found that two emergency event types were significantly associated with the odds ratio: explosions and hurricanes. Assuming the hypothesis above about overcrowding and the spread of infectious disease is true, this finding makes sense; hurricanes have much larger evacuation areas and result in much larger populations in shelters or other housing, increasing the risk of infectious disease spread. By contrast, explosions damage relatively small areas, meaning evacuees are much less likely to be sharing cramped or overcrowded quarters. Figure 4-57 shows that a meta-regression of the prevalence in displaced populations found that only the time between the event and the study was significant, with increased time associated with a lower prevalence. This finding suggests that the effect is short lived and will resolve over time, which would be consistent with respiratory infections such as colds, flus, or similar illnesses.

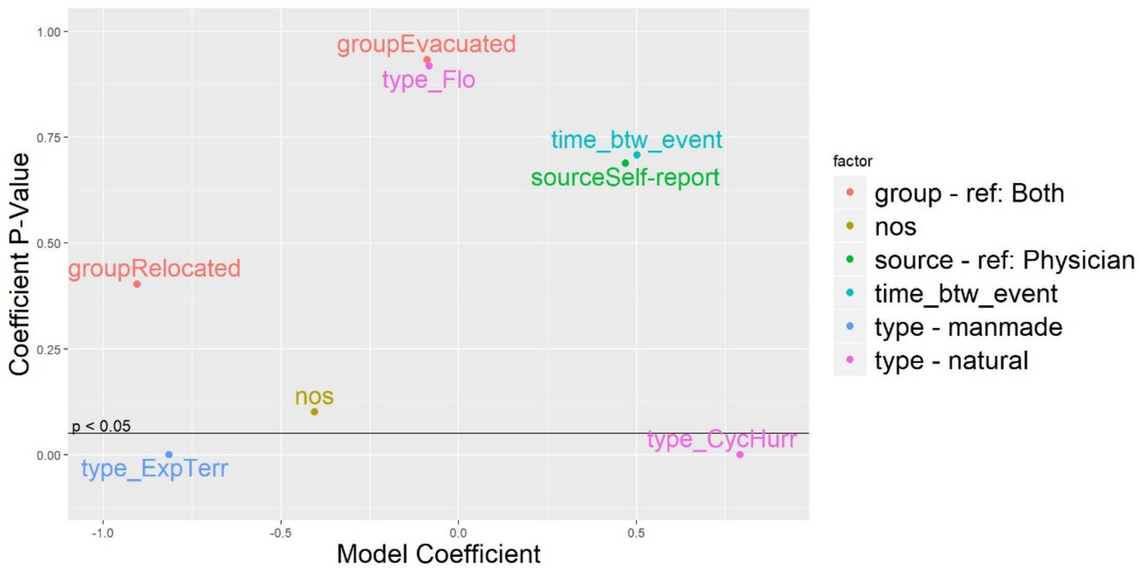

Figure 4-56 Meta-regression of Odds Ratio for Respiratory Problems

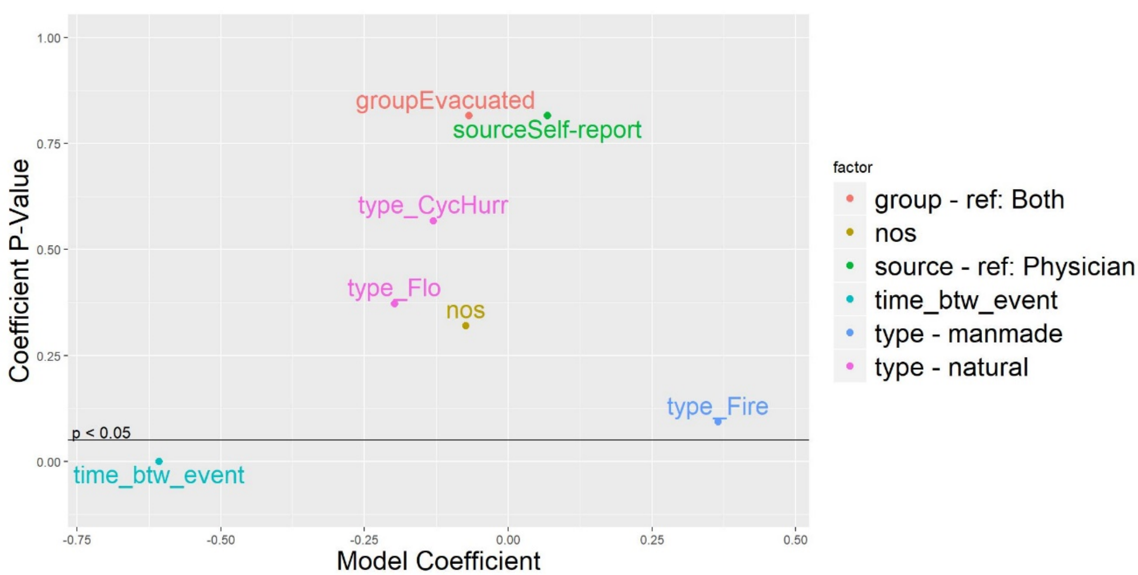

Figure 4-57 Meta-regression of Prevalence of Respiratory Problems in Displaced Populations

4.1.11 Sleep Problems

The sleep problems analysis included all papers in which displaced or nondisplaced populations reported trouble falling asleep or getting enough sleep. Sleep problems is a wide category encompassing a myriad of different sleep-related issues, including sleep duration, nightmares, use of sleep medication, and others. Papers included focused on the prevalence of nonspecific sleep problems in medical records, self-reporting or measurement of sleep quality, interviews using the Athens insomnia scale or similar insomnia instruments, and broad sleep quality index questionnaires. The data did not contain specific focus on sleep apnea or narcolepsy, except so far as they caused sleep disturbances or impaired functioning during the daytime. Typically, the individual studies did not provide odds ratio data for sleep problems; however, the meta-analysis identified a statistically significant association between sleep problems and displacement (Figure 4-58). Additionally, all the data were statistically significant. This relationship is also observable from the prevalence data. While data were insufficient to perform a meta-regression on sleep problems in displaced populations alone, comparing the prevalence in displaced populations with the prevalence in nondisplaced populations showed a wide disparity, as shown in Figure 4-59 and Figure 4-60, respectively. There is likely a causal relationship between displacement and sleep problems, as evacuees cope with the stress reactions and psychological distress caused by the evacuation and of not knowing whether or when it will be safe to return to their original homes (Dirkzwager, 2006b; Ohira, 2016b). Also, populations displaced from their homes are likely to be far less comfortable sleeping in hotels, shelters, or other temporary residences.

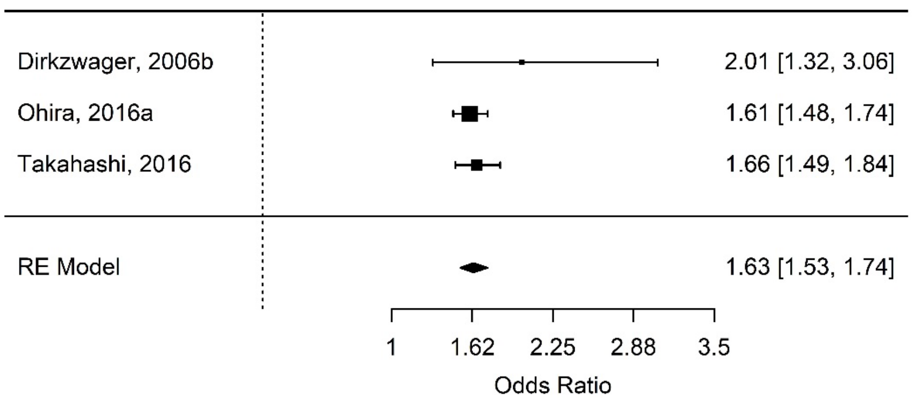

Figure 4-58 Meta-analysis of Odds Ratio for Sleep Problems

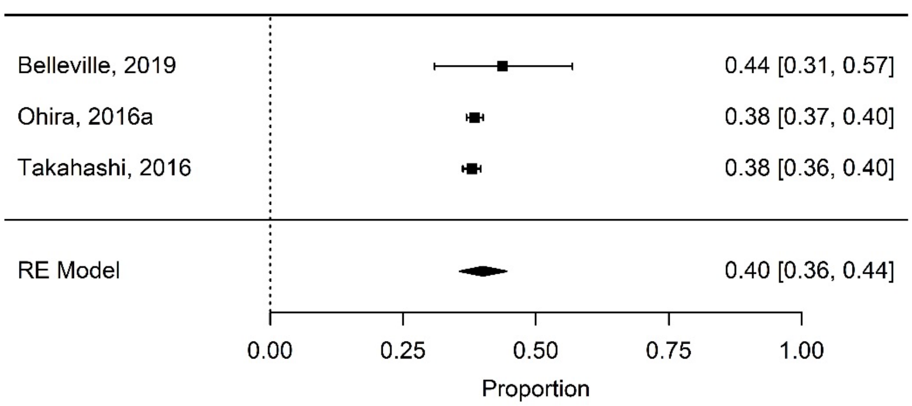

Figure 4-59 Prevalence of Sleep Problems in Displaced Populations

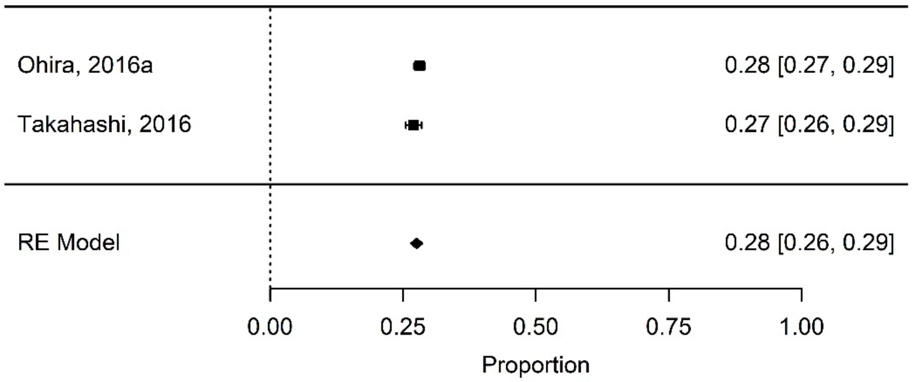

Figure 4-60 Prevalence of Sleep Problems in Nondisplaced Populations

The meta-regression of odds ratio data (Figure 4-61) showed no individual variables significantly associated with observed sleep problems. The literature review did not identify enough data on prevalence in displaced or nondisplaced populations separately to support a meta-regression. Although the odds ratio meta-regression did not reveal any significantly associated variables, several at-risk groups and other potential factors could be driving sleep problems. Children are likely at particular risk for sleep problems. In a study of all children who experienced the 2001 Netherlands Fireworks Disaster, children between 4 and 12 years old had the largest jump in sleep problems following the disaster compared to the control group, with some reporting sleeping problems persisting 2 years after the disaster (Dirkzwager, 2006b). A study of Italian factory workers who suffered an earthquake in 1980 found that those who had to evacuate from later earthquakes in 1983–1984 were more likely to report sleeping problems, among other negative effects, regardless of age or education (Bland, 1996). Other factors can lead to sleeping problems. A study following a population exposed to a wildfire found that individuals in homes sustaining fire damage were almost 30 percent more likely to report sleeping problems 2 weeks after the event. Exposure to multiple emergency events of the same kind or having significant property damage during an event are also risk factors for psychological distress and PTSD, suggesting that sleep problems may reflect these effects as well. Analysis of sleep problems suffers from the common issue of sleep-wake misperception, where people cannot reliably report the quality of their sleep. Sleep problems, PTSD, and psychological distress are related to a more sustained anxiety reaction. Sleep requires the ability to turn down anxiety in favor of less activating thoughts to promote drowsiness.

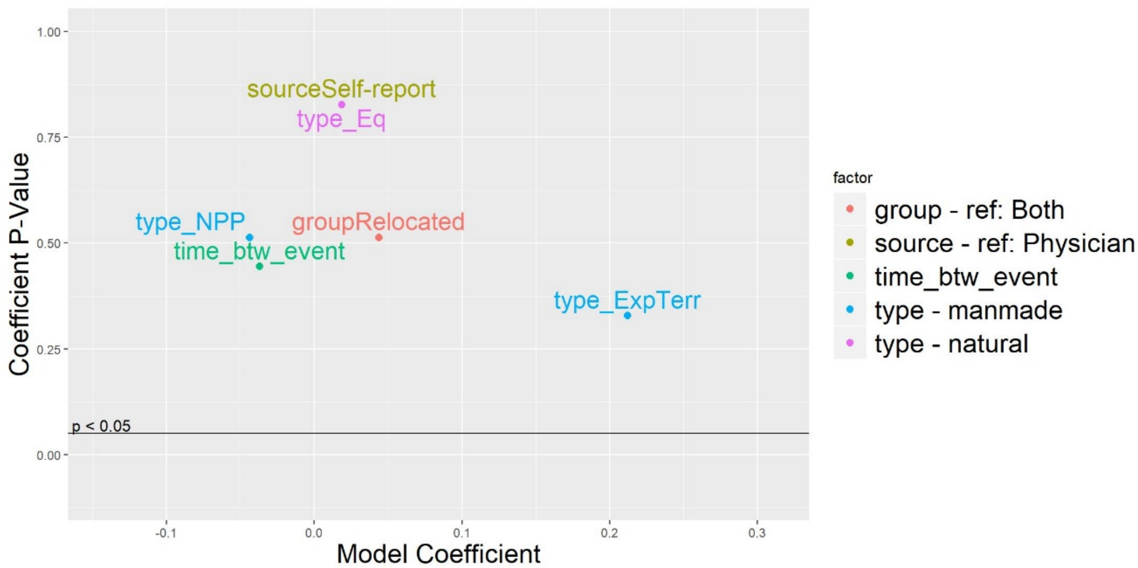

Figure 4-61 Meta-regression of Odds Ratio for Sleep Problems

4.1.12 Substance Abuse

The substance abuse analysis included papers reporting smoking, abuse of alcohol or other recreational substances, and substance misuse. No specific studies were found on the misuse of prescription opioids. The meta-analysis (Figure 4-62) found a small increase in substance abuse associated with evacuation or relocation. This finding is borne out by the roughly similar prevalence of substance abuse among displaced populations and nondisplaced populations, shown in Figure 4-63 and Figure 4-64, respectively. Although somewhat surprising, given that substance abuse can be an unhealthy coping mechanism for stress or trauma, the lack of a statistically significant relationship means that evacuation or relocation does not necessarily lead to a significant increase in this behavior.

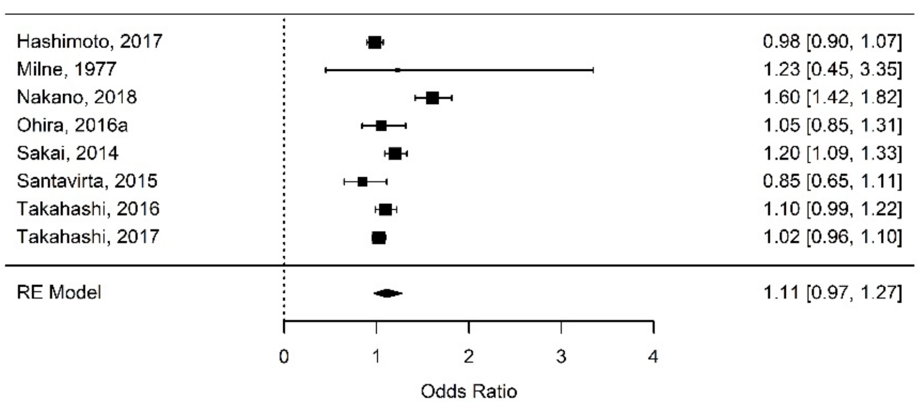

Figure 4-62 Meta-analysis of Odds Ratio for Substance Abuse

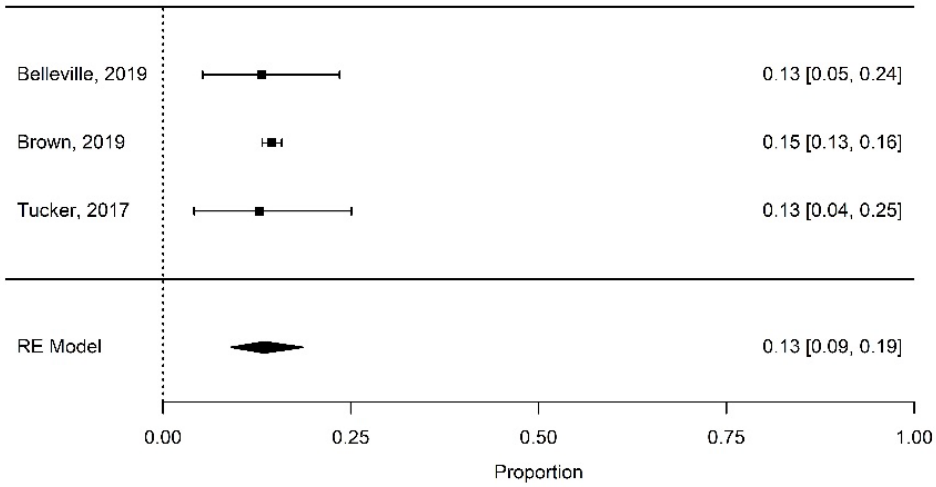

Figure 4-63 Prevalence of Substance Abuse in Displaced Populations

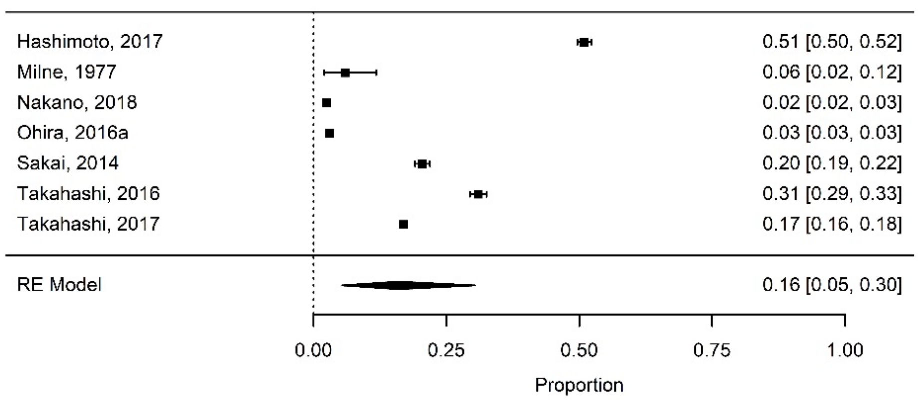

Figure 4-64 Prevalence of Substance Abuse in Nondisplaced Populations

Figure 4-65 shows that the meta-regression of odds ratio data found that reliance on populations self-reporting substance abuse problems was associated with higher odds ratios than use of physician-diagnosed substance abuse problems. This variation is not unexpected, as many individuals may have problems with substance abuse but do not seek treatment or their problems do not rise to the level of requiring intervention. The prevalence data (Figure 4-66), however, show no individual variables that are significant.

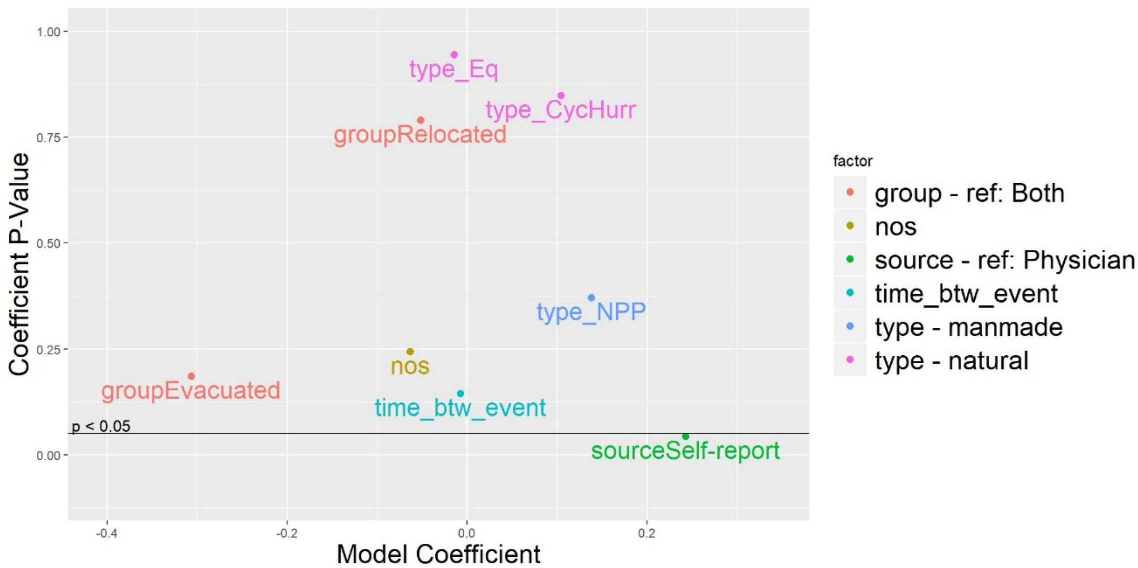

Figure 4-65 Meta-regression of Odds Ratio for Substance Abuse

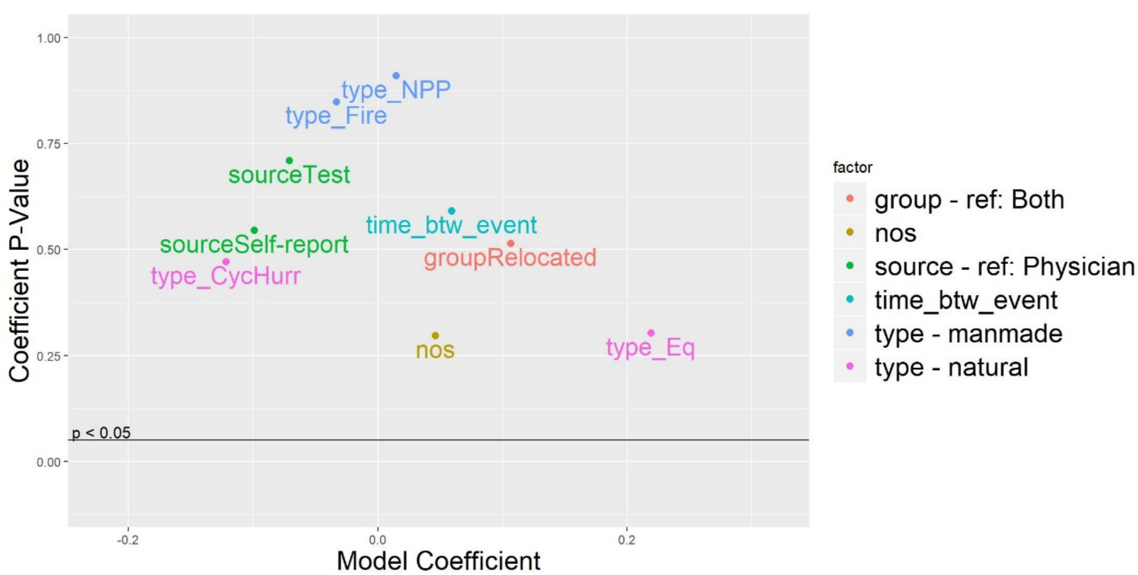

Figure 4-66 Meta-regression of Prevalence of Substance Abuse in Displaced Populations

4.1.13 Weight Problems

The meta-analysis for weight problems included all reports of underweight or overweight populations and any reports of sudden weight loss or gain following an incident. The meta-analysis for weight problems (Figure 4-67) found a statistically significant association between weight problems, including both increase and decrease in weight, and displacement with an overall odds ratio of 1.43. This finding was significant in all but one paper included in the analysis, and weight problems had a reported odds ratio greater than 1.0 in all of them, suggesting that observing this effect is very common during emergency events. However, the overall prevalence of these health problems is relatively high in both displaced and nondisplaced groups, as shown in Figure 4-68 and Figure 4-69. As weight problems likely result from a disruption of routine, it is reasonable to expect at least some weight problems among displaced and nondisplaced populations because these populations will still have disrupted routines and potentially different eating habits. Remaining at home allows populations to keep at least some of their routines, compared to populations that may be in shelters or hotels in unfamiliar areas.

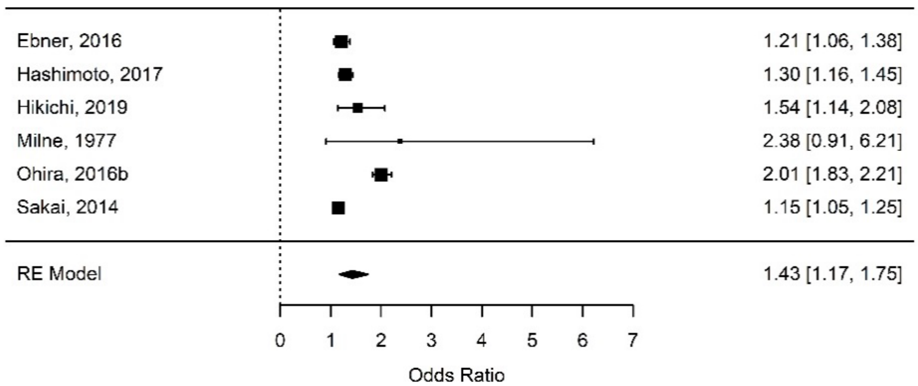

Figure 4-67 Meta-analysis of Odds Ratio for Weight Problems

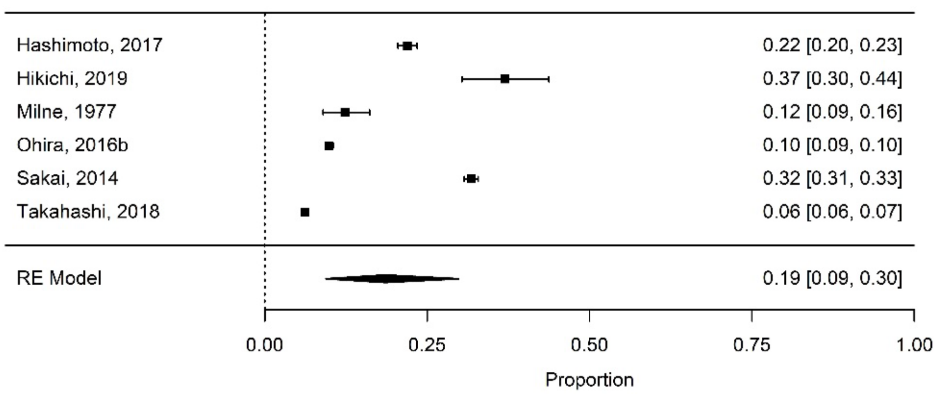

Figure 4-68 Prevalence of Weight Problems in Displaced Populations

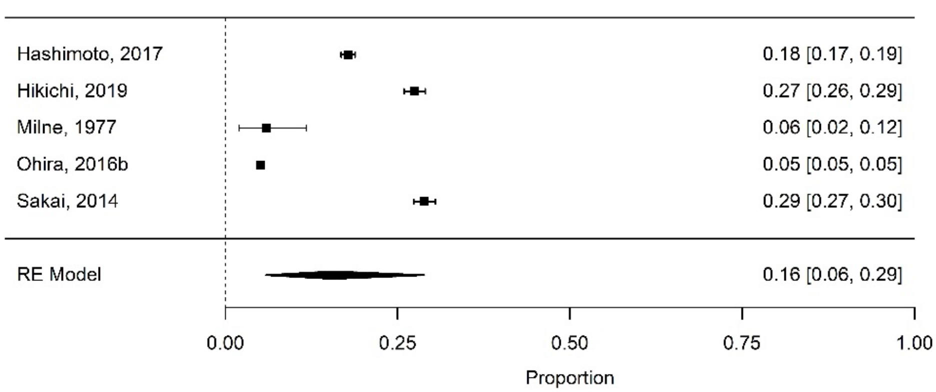

Figure 4-69 Prevalence of Weight Problems in Nondisplaced Populations

The meta-regressions of the odds ratio data (Figure 4-70) and the prevalence data (Figure 4-71 and Figure 4-72) found only one variable that was significant: the NOS score of the study. Papers that had a higher NOS score (meaning papers that had a generally more robust methodology) had a lower odds ratio for weight problems. NOS scores for these papers ranged from 4 to 7, with all but one scoring either 6 or 7. This effect is not due to the one outlier with a NOS score of 4, however, as there is also a difference between the papers that scored 6 and 7, albeit not as large. This is an interesting finding, but given the overall high score of the papers in the study, it does not invalidate the evidence of a real population-level effect. As this variable does not appear to be significant in the prevalence data, it is not clear whether these papers are detecting a greater prevalence of weight problems in the nondisplaced populations, a smaller prevalence of weight problems in the displaced population, or some combination of both.

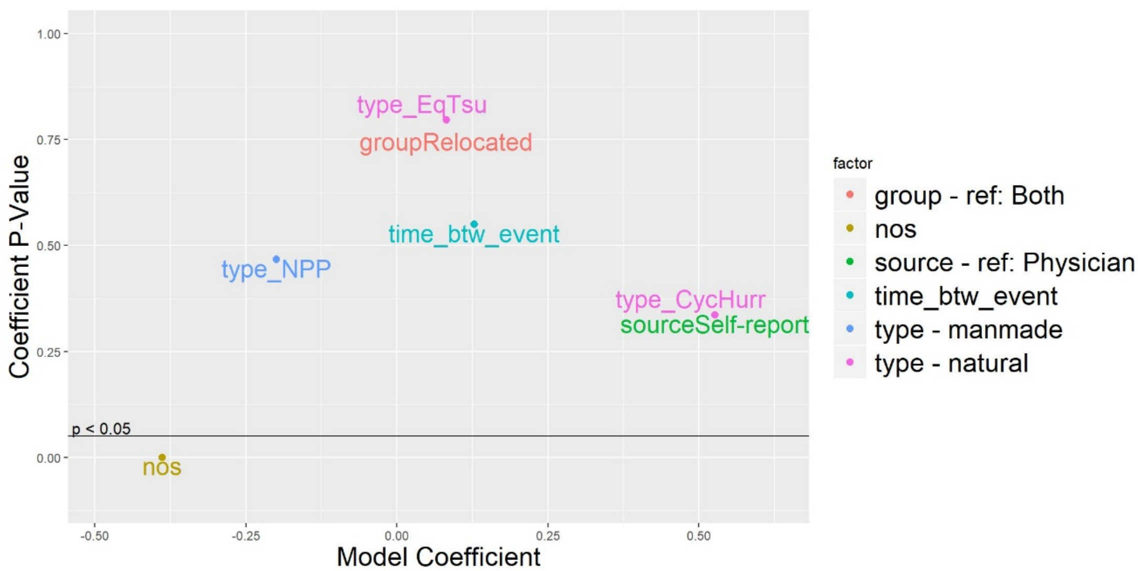

Figure 4-70 Meta-regression of Odds Ratio for Weight Problems

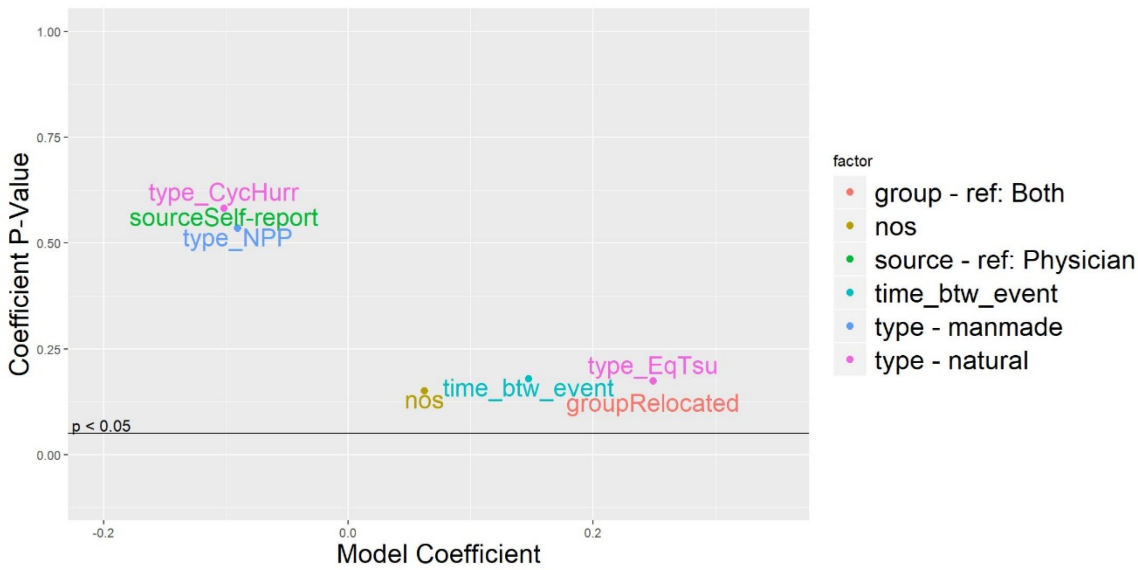

Figure 4-71 Meta-regression for Prevalence of Weight Problems in Displaced Populations

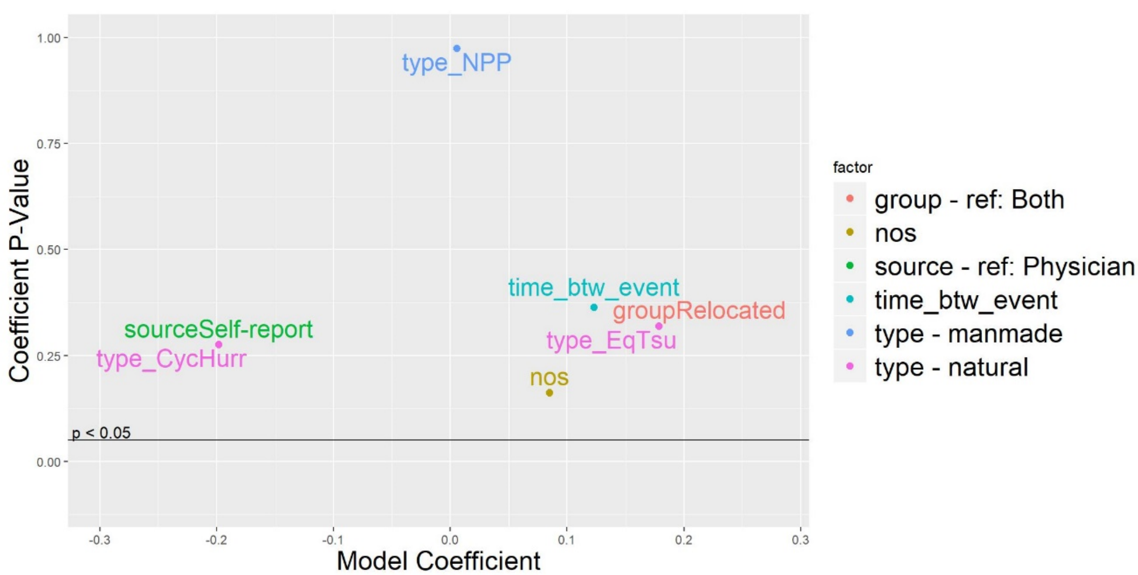

Figure 4-72 Meta-regression for Prevalence of Weight Problems in Nondisplaced Populations

4.1.14 Other Effects

The other effects category is a broad category that captures loss of social and support networks, children with reported memory problems, experience of abuse during evacuation, and other symptoms that were referred to general practitioners following emergency department visits. This category captures many of the negative outcomes not otherwise captured in the other categories. The meta-analysis (Figure 4-73) found an extremely significant relationship between evacuation or relocation and an increase in these problems. This large effect is borne out in the prevalence data when the prevalence of other effects is compared for displaced and nondisplaced populations (Figure 4-74 and Figure 4-75, respectively). This finding highlights the power of performing these analyses side by side, because the relationship between evacuation or relocation and these effects is only apparent when the odds ratios for the pairs of displaced and nondisplaced populations for each emergency are compared.

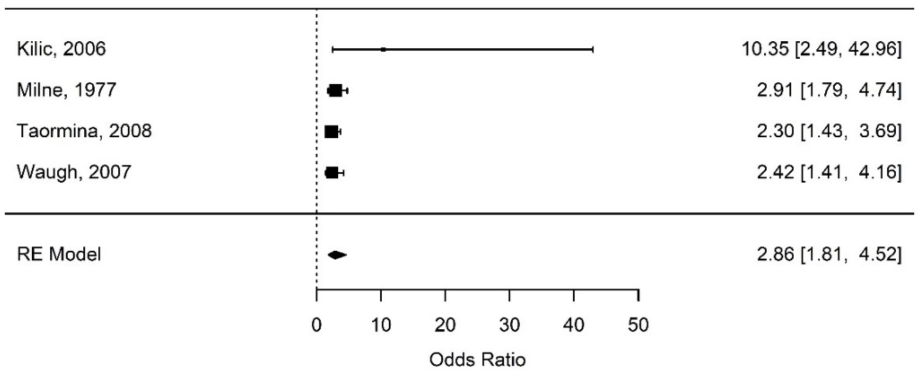

Figure 4-73 Meta-analysis of Odds Ratio for Other Effects

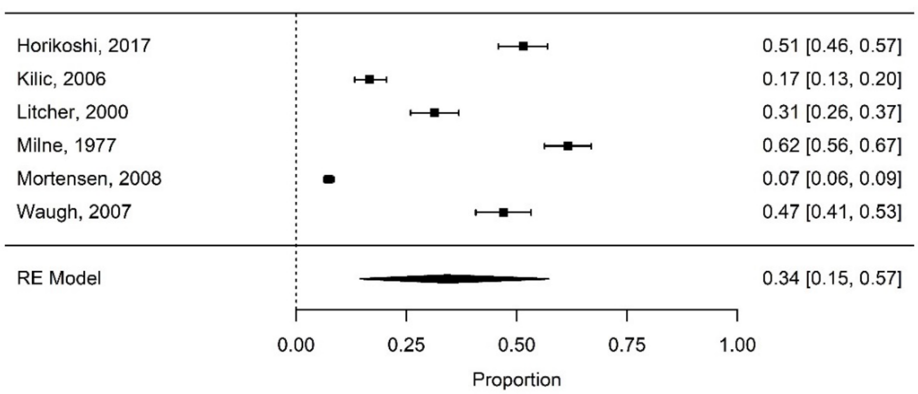

Figure 4-74 Prevalence of Other Effects in Displaced Populations

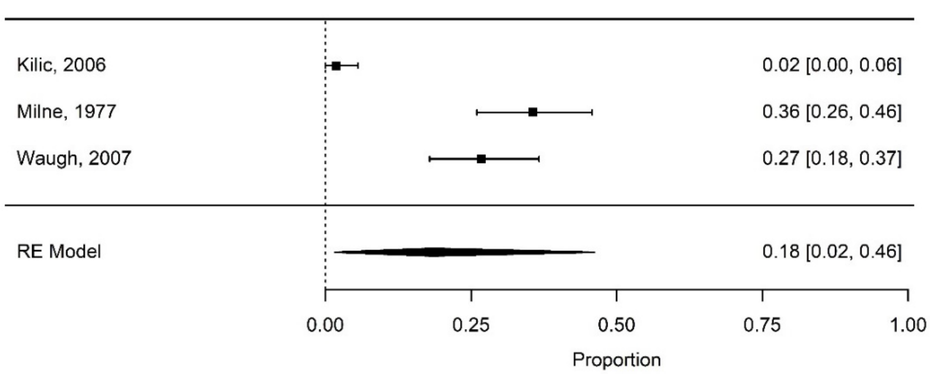

Figure 4-75 Prevalence of Other Effects in Nondisplaced Populations

The meta-regression (Figure 4-76) found only one significant variable in determining the odds ratio for other effects: explosion events. This finding could indicate that smaller evacuated areas lead to less displacement overall and, therefore, less loss of social and support networks compared to other emergency types where displacement distances may be greater. Interestingly, compared to the overall population, both evacuated and relocated populations are associated with lower prevalence of other effects compared to all displaced and nondisplaced populations, as demonstrated in Figure 4-77.

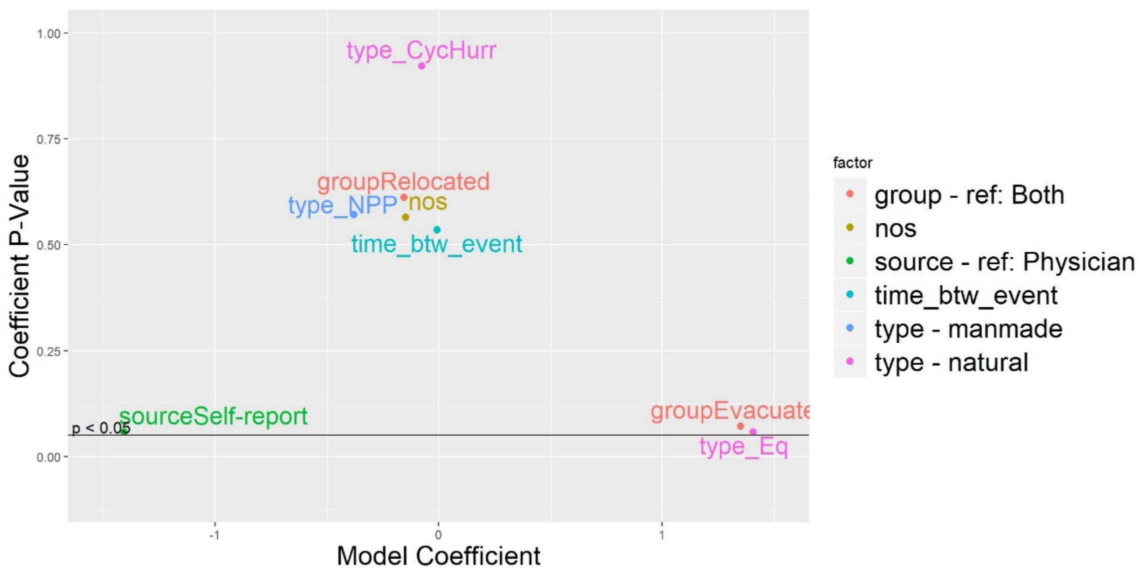

Figure 4-76 Meta-regression of Odds Ratio for Other Effects

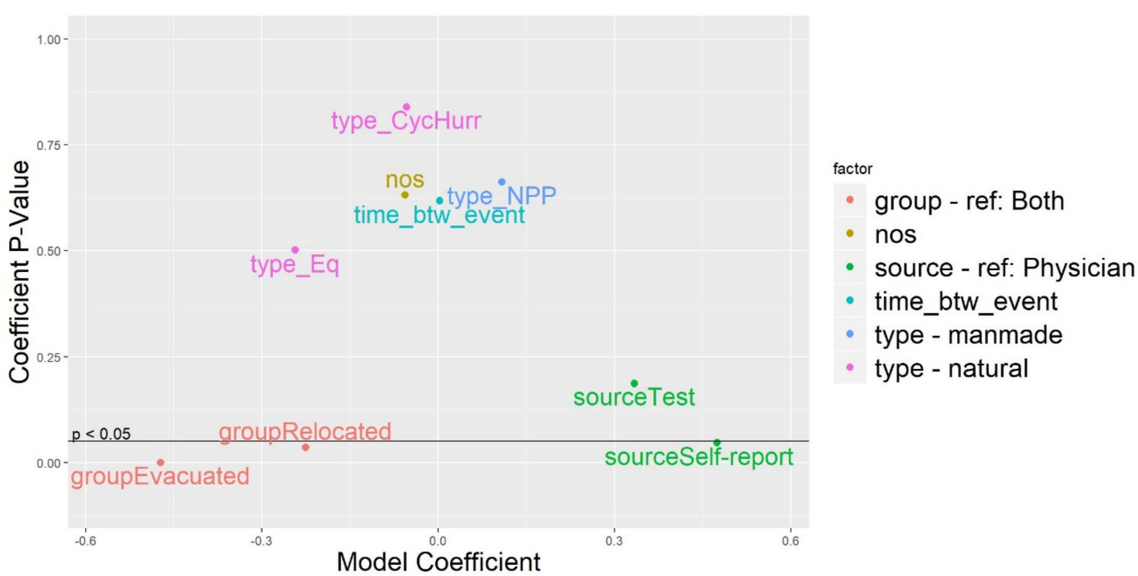

Figure 4-77 Meta-regression of Prevalence of Other Effects in Displaced Populations

4.2 All Health Effects

A meta-analysis across all health effects included in this analysis revealed a significant relationship between evacuation or relocation and an increase in negative health effects, as shown in Figure 4-78. The overall odds ratio of 1.49 (95-percent confidence interval: 1.24–1.79) suggests that additional consideration should be given to the health risks to populations displaced for prolonged periods of time. For radiological emergencies, these health risks should be carefully balanced against radiation risks or other risks populations would experience if they were not evacuated.

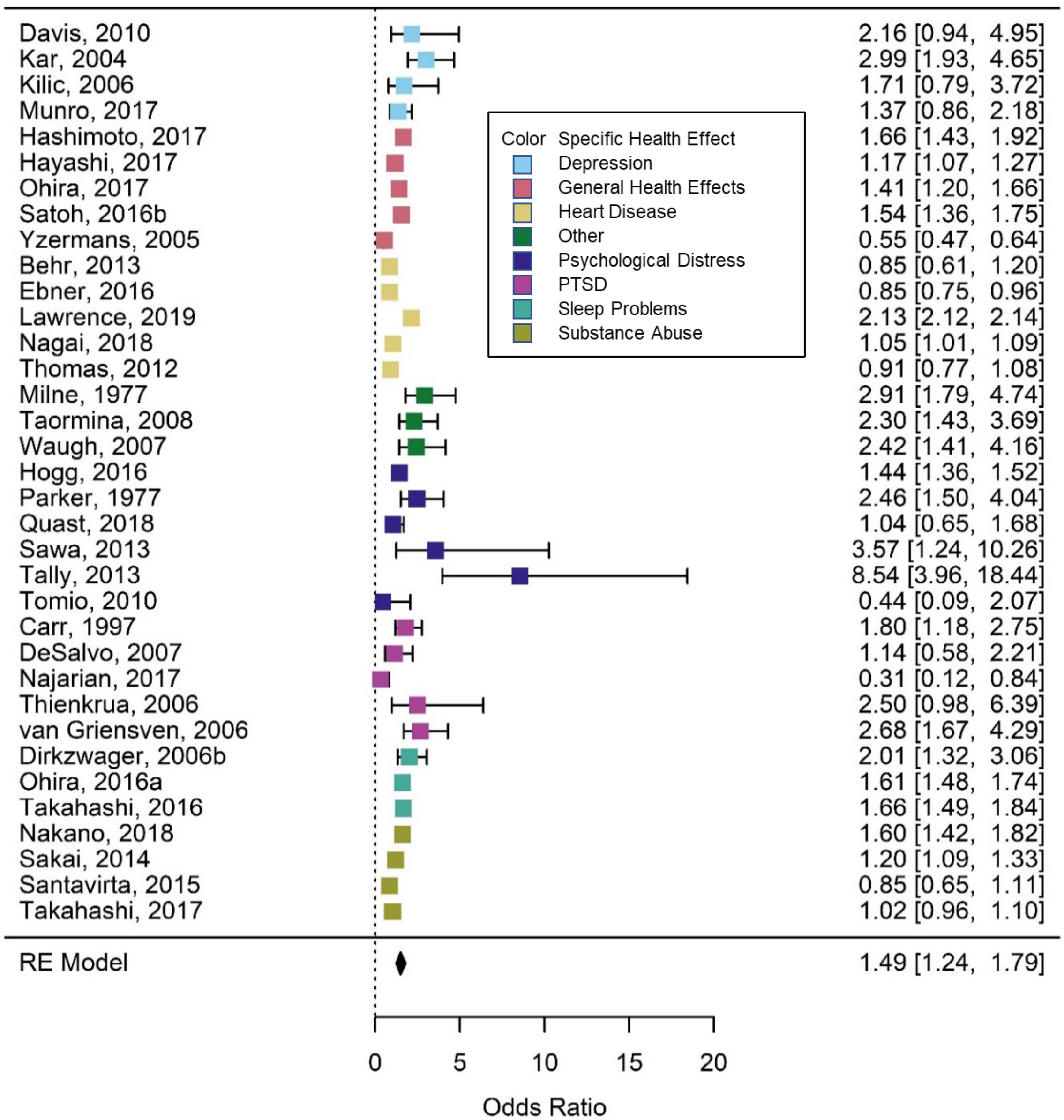

Figure 4-78 Meta-analysis of Odds Ratio for All Health Effects

A meta-regression of the odds ratio analysis (Figure 4-79) found only one significant variable, which was wildfires. Across all health effects, wildfires are associated with greater odds ratios, that is, greater amounts of negative health effects in displaced populations compared to nondisplaced populations. By contrast, all of the other factors considered are clustered around a model coefficient of 0, indicating no relationship between that factor and the odds ratio. Nuclear power plant accidents are just slightly negative, suggesting that odds ratio for all health effects is slightly smaller for these accidents, but the *p*-value is very high ($p > 0.5$).

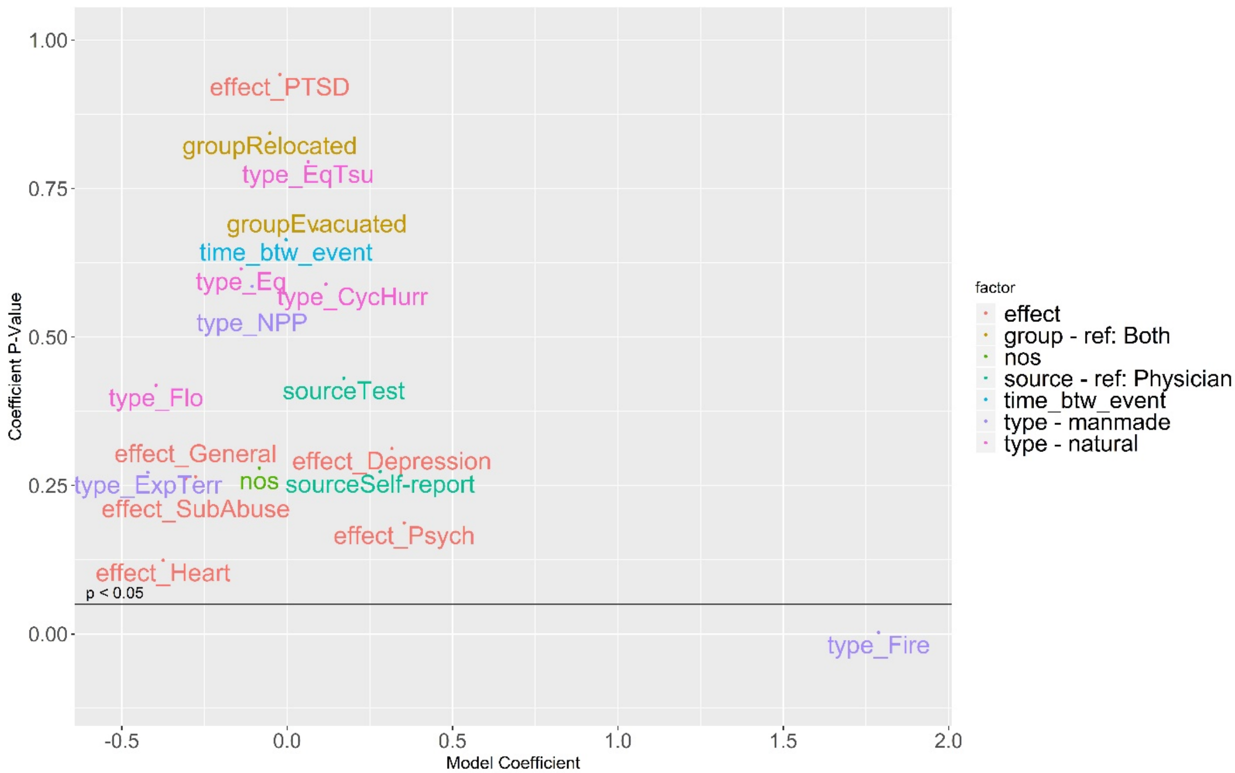

Figure 4-79 Meta-regression of Odds Ratio for All Health Effects

Across all the health effects examined, traditional psychological effects (included in the analyzed health effects) show a similar pattern. Anxiety and depression, for example, are commonly related in clinical psychiatric practice and were both found to increase in displaced populations. Further, PTSD is a type of anxiety disorder, meaning its apparent correlation with anxiety and depression is to be expected. Psychological distress is an overarching term for those whose emotional distress shows different clinical signs and symptoms. Sleep is commonly a problem for those with emotional turmoil. Disturbances can cause irritability and decreased concentration and can strain the quality of interpersonal connections. Alcohol or other substances are widely available to temporarily numb an individual from a difficult reality. Food, often abundant in high-calorie unhealthy options even after an emergency event, is often used for self-soothing. This results in weight gain and all its consequences. Weight loss, although less common in anxiety and depression, may be of more immediate concern clinically.

This analysis of health effects also included the risks for traditional physical health effects, including diabetes, heart disease, and respiratory problems. The endocrine response to stress, primarily through the hypothalamic-pituitary-adrenal axis and the production of cortisol (Smith, 2006), when sustained, can cause insulin resistance (Kennedy, 2010). Chronic disease management (including following a diabetic diet) can be difficult during relocation. Cortisol is independently associated with atherosclerotic disease, including coronary artery disease (Yao, 2019). Respiratory disease, often secondary to smoking (about 15 percent of Americans) and asthma (about 8 percent of the U.S. population and increasing), also requires chronic disease management and is often closely related to atherosclerotic heart disease. Smoking, as a response to stress, may increase in the aftermath of an emergency event. Smoking is well known to have broad-ranging health consequences that exacerbate diabetes, cause heart disease, and lead to death.

Just as psychological distress was an umbrella term for traditional psychological variables, general health effects can be seen as an overarching term encompassing diabetes, heart disease, and respiratory problems. As noted above, sleep, substance abuse, and weight problems are associated with psychological health but have undisputed effects on general (physical) health. Poor sleep, for example, affects general health through higher cortisol levels (Basta, 2007). Substance abuse as a way to work through a traumatic relocation is ineffective and may kick off a pattern of dependence and all its negative health effects. Weight problems, primarily excessive caloric intake, are legion in American society, and relocations (even vacations) are times when people often set aside any sensible nutritional discipline.

In summary, stress from an event for which relocation or evacuation is being considered is likely to have significant health effects. Relocating or evacuating adds to or even compounds this stress reaction with many health effects, both psychological and physical.

4.3 Estimated Magnitude of Effects

One of the limitations of the meta-analyses conducted across all the health outcomes is that the aggregated proportion and odds ratio effect sizes do not translate into directly comparable measures across the different health outcomes. It is possible to compare odds ratios and surmise that an odds ratio of 1.8 is a greater effect size than an odds ratio of 1.2; however, these measures alone explain nothing of the potential risk to a displaced population. If, for example, health outcome X is associated with a higher odds ratio but has a much lower prevalence in the nondisplaced population than health outcome Y, then the higher odds ratio for X might not mean that more people will experience X than Y, if displaced. To address this issue, a risk difference analysis was performed to examine and compare the magnitude of the aggregate effect sizes across all the different health outcomes. This analysis used the estimated odds ratios and proportion values for each health outcome in the study to capture the additional risk of each health effect in an example population.

To calculate the additional risk experienced by displaced populations, the risk difference between the nondisplaced and displaced populations was calculated for each health effect in the study. The proportion values were used to estimate an underlying number of individuals in both displaced and nondisplaced example populations that experience a negative health effect (e.g., experiencing symptoms of PTSD for the PTSD health effect). This calculation considered a sample population of 200,000 individuals, with half (100,000) evacuating or relocating while the other half (100,000) did not evacuate or relocate. For the nondisplaced population, the estimated proportion, $\widehat{P_n}$ (see Section 3.1.2), was used to estimate the number of individuals reporting each health effect, as shown in Equation 4-1:

$$\widehat{P_n} = \frac{N_n}{N} \qquad (4\text{-}1)$$

In Equation 4-1, N_n is the number of nondisplaced individuals experiencing the health effect, and N is the total number of nondisplaced individuals. Using the number of nondisplaced healthy individuals (H_n from Table 3-1), and the estimated odds ratio for the health effect (Equation 3-3), a system of equations was developed to solve for the estimated number of individuals reporting the health effect after evacuation:

$$\frac{\widehat{OR} * N_n}{H_n} = N_d/H_d \tag{4-2}$$

In Equation 4-2, the meta-analysis odds ratio ($\widehat{OR}$), N_n, and H_n are assumed to be known quantities (estimated through meta-analysis), while N_d and H_d are solved for. Finally, the value N_d, the estimated number of displaced individuals expected to experience a negative health outcome, is used to calculate the risk difference between the two populations for the health effect, as shown in Equation 4-3:

$$\widehat{RD} = N_d - N_n \tag{4-3}$$

The estimated risk difference was then calculated for the bounds of the confidence interval for the odds ratio to capture a measure of uncertainty about the risk difference. This procedure was performed for all the health effects for which odds ratio measures were estimated. As the estimated odds ratios were all greater than 1.0, with some including evidence that the 95-percent confidence interval bounds were also above 1, the estimated risk difference was greater than 0 for all health effects, as shown in Figure 4-80.

This analysis shows the difference in the effect size on at-risk populations for various health effects in a simplified example population evacuating or relocating from a nonspecific emergency event. This analysis explores the more nuanced relationship between the estimated odds ratio and the number of expected individuals who might experience a negative health outcome. For example, the effect size for healthcare accessibility problems was estimated to be 2.04 (95-percent confidence interval: 0.81–5.18). However, the proportion of the nondisplaced population experiencing healthcare accessibility problems was only 0.10 (95-percent confidence interval: 0.05–0.15), which means that the expected number of additional individuals experiencing accessibility problems was not as large as some of the other health effect sizes, including those with smaller odds ratios (e.g., psychological distress, sleep problems). The odds ratio effect size for psychological distress was estimated at 1.68 (95-percent confidence interval: 1.19–2.38) but the underlying nondisplaced proportion effect size was estimated at 0.24 (95-percent confidence interval: 0.18–0.30), meaning that the total risk difference estimate was much higher (almost 13,200 per 100,000 individuals) than for other health effects.

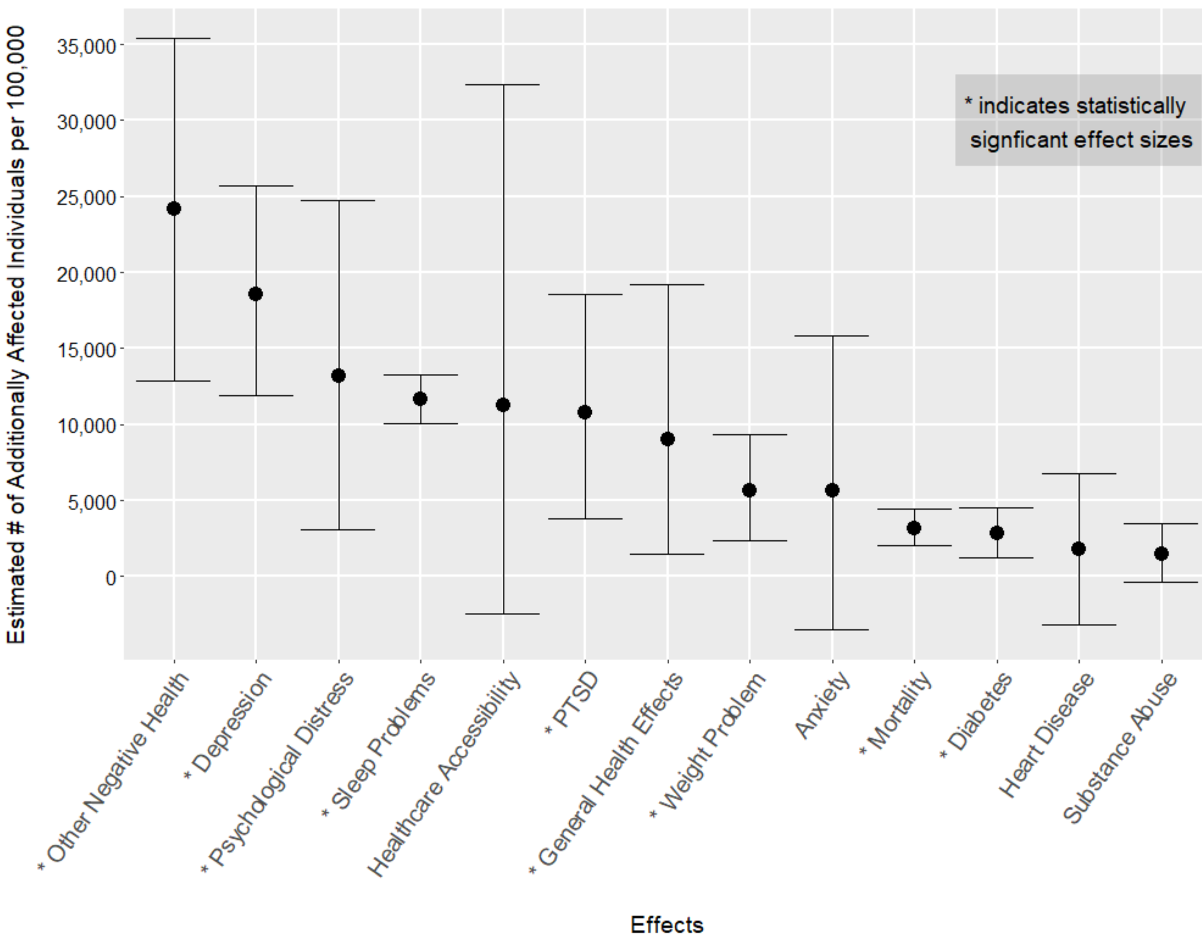

Figure 4-80 Estimates of the Number of Additional People Experiencing Health Effects per 100,000 Displaced Individuals Compared to Nondisplacement

This analysis has several limitations in both methodology and interpretation. First, as any individual may suffer from more than one health effect—and is in fact likely to in many cases—the magnitudes of each health effect cannot be summed to generate an overall number of individuals harmed. By contrast, the largest effect, other health effects, can be used as a minimum number of people negatively affected. As it is unlikely all individuals with health effects caused by displacement would suffer from one of the miscellaneous effects, using the other miscellaneous effects category as a minimum would likely be an underestimate of the overall number of people harmed. Second, the estimated size of the health effect for nondisplaced populations was used to calculate an underlying rate of illness, but the uncertainty in this proportion was not propagated through the analysis. Both this proportion estimate and the odds ratio estimates were calculated with uncertainty (confidence intervals), but only the confidence interval bounds from the odds ratio analysis could be used in this estimate because of the complexity in propagating the error of a random variable solved for using a system of equations. Third, this calculation does not make use of the estimated proportion of individuals that might experience a negative health incident in the displaced population explicitly. The small difference in the proportions of displaced individuals experiencing a negative health event between the meta-analysis and this estimated value is due to the difference in the proportions of individuals who evacuated or relocated from the included studies in each meta-analysis, the uncertainty in the proportionality and odds ratio data, and the difference samples for the two values. Finally, these estimated values denote an estimate of the association between displacement and negative health outcomes but do not illustrate any explicit causal relationship between displacement and the negative health outcomes. As such, it would not be a valid statistical procedure to use the odds ratios to predict the number of affected individuals following an emergency event or to predict individual health outcomes.

Applying these magnitude estimates to inform emergency evacuations requires an understanding of the evacuated populations used to develop the data for each health effect. For example, the mortality analysis has an average estimated size of approximately 3,000 additional deaths per 100,000 people evacuated. Since this estimate is based primarily on evacuation of hospitals and nursing homes, there is no expectation that the general public would see an additional 3-percent mortality following displacement. Instead, this estimate is best applied to evacuated populations currently in hospitals, nursing homes, or elderly care facilities. Table 4-3 and Table 4-4 show the specific special populations used to develop each estimate. The proportion studies and the odds ratio studies were both used in developing the magnitude estimates, so both sets of special populations need to be considered when determining how these estimates may apply.

Table 4-3 Number of Studies for Each Health Effect and Special Populations Included

Health Outcome	Number of Studies	Number of Studies with Special Population	Special Populations Included
Anxiety	10	3	Children
Depression	17	6	Children, Mothers
Diabetes	5	1	Elderly
General Health Effects	12	1	Mothers
Healthcare Accessibility	5	1	Elderly
Heart Disease	8	1	Elderly
Mortality	4	3	Hospital Patients, Nursing Home Residents
Other	6	1	Mothers
Psychological Distress	21	5	Children, Mothers
PTSD	27	6	University Students, Children
Respiratory Problem	4	0	
Sleep Problems	3	0	
Substance Abuse	10	0	
Weight Problem	6	0	

Table 4-4 Number of Odds Ratio Studies for Each Health Effect and the Special Populations Included

Health Outcome	Number of Studies	Number of Studies with Special Population	Special Populations Included
Anxiety	3	0	
Depression	7	2	Children
Diabetes	9	1	Elderly
General Health Effects	11	2	Elderly, Males
Healthcare Accessibility	4	1	Elderly
Heart Disease	9	2	Elderly
Mortality	5	4	Hospital Patients, Nursing Home Residents
Other	4	1	Low-educated Mothers
Psychological Distress	10	2	Children, Hospitalized Patients
PTSD	10	3	University Students, Children
Respiratory Problem	4	1	Elderly
Sleep Problems	3	0	
Substance Abuse	8	1	Children
Weight Problem	6	0	

5 CONCLUSION

In this study, the meta-analysis has shown that an increase in negative health outcomes is associated with evacuation and relocation. The estimated magnitude of these effects, ranging from mortality to disruption in social networks, is quite large. The largest effect is that nearly 25,000 additional people affected per 100,000 people displaced would potentially suffer from "other health effects," covering disruption of social support networks, increases in domestic abuse, and memory problems in children, among others. The analysis found substantial and statistically significant increases in depression, psychological distress, PTSD, sleep problems, and mortality, among others, for evacuated and relocated populations relative to nondisplaced populations. While many of the health effects identified in this analysis are not disabling or could be relatively short lived, they still represent a sizeable health burden on evacuated or relocated populations.

Perhaps the most important conclusion of this report is that there are significant deleterious effects from evacuating and relocating populations. This information can be used to better risk-inform policy, planning, strategies, and procedures for protective actions used in response to a variety of hazardous events, including radiological emergencies. The findings of this study suggest that evacuation and relocation should not be used purely out of an abundance of caution. Populations that are unnecessarily displaced gain no benefit from unwarranted protective actions and will potentially suffer health effects for years as a result. For radiological emergencies, protective actions are risk-informed and carefully planned to ensure the benefit of avoiding or reducing exposure to radiation is not outweighed by the risk to health from a protective action. Consideration of the health effects of prolonged evacuation and relocation in balancing the risk can enhance public safety and will help to support protective actions doing more good than harm.

6 REFERENCES

Acierno, R., et al. “Psychological sequelae resulting from the 2004 Florida hurricanes: Implications for postdisaster intervention,” *Am J Public Health*, 97 Suppl 1, pp. S103–8, 2007. (Acierno, 2007).

Adler, N., Ostrove, J. “Socioeconomic status and health: What we know and what we don’t,” *Annals of the New York Academy of Science*, 896, 3–15, 1999. (Adler, 1999).

Anderson, A.H., et al. “Missed dialysis sessions and hospitalization in hemodialysis patients after Hurricane Katrina, *Kidney Int*, 75, 1202-1208, 2009. (Anderson, 2009).

Andrews, G., Slade, T. “Interpreting scores on the Kessler Psychological Distress Scale (K10), *Australian and New Zealand Journal of Public Health*, 25, 494–497, 2001. (Andrews, 2001).

Baker, K. “Reflection on lessons learned: An analysis of the adverse outcomes observed during the Hurricane Rita evacuation,” *Disaster Med Public Health Prep*, 12, 115–120, 2018. (Baker, 2018).

Barendregt, J.J., et al. “Meta-analysis of prevalence,” *Journal of Epidemiology and Community Health*, 67, 974–978, 2013. (Barendregt, 2013).

Basta, M., et al. “Chronic insomnia and stress system,” *Sleep Med Clin*, 2, 279–291, 2007. (Basta, 2007).

Behr, J.G., Diaz, R. “Disparate health implications stemming from the propensity of elderly and medically fragile populations to shelter in place during severe storm events,” *J Public Health Manag Pract*, 19 Suppl 2, S55–62, 2013. (Behr, 2013).

Belleville, G., Ouellet, M.C., Morin, C.M. “Post-traumatic stress among evacuees from the 2016 Fort McMurray wildfires: Exploration of psychological and sleep symptoms three months after the evacuation,” *Int J Environ Res Public Health*, 16(9), 1604, 2019. (Belleville, 2019).

Bernard, A.M., et al. “Comparing the hospitalizations of transfer and non-transfer patients in an academic medical center,” *Acad Med*, 71, 262–6, 1996. (Bernard, 1996).

Blanchard, G., Dosa, D. “A comparison of the nursing home evacuation experience between Hurricanes Katrina (2005) and Gustav (2008), J *Am Med Dir Assoc*, 10, 639–43, 2009. (Blanchard, 2009).

Bland, S.H., et al. “Long-term psychological effects of natural disasters,” *Psychosom Med*, 58, 18–24, 1996. (Bland, 1996).

Borenstein, M. *Introduction to meta-analysis*, John Wiley & Sons, Chichester, U.K., 2009. (Borenstein, 2009).

Bowler, R.M., et al. “Posttraumatic stress disorder, gender, and risk factors: World Trade Center Tower survivors 10 to 11 ayears sfter the September 11, 2001 attacks,” *J Trauma Stress*, 30, 564–570, 2017. (Bowler, 2017).

Bremner, J.D. "Traumatic stress: Effects on the brain," *Dialogues Clin Neurosci*, 8, 445–61, 2006. (Bremner, 2006).

Briere, J., Elliott, D. "Prevalence, characteristics, and long-term sequelae of natural disaster exposure in the general population," *J Trauma Stress*, 13, 661–79, 2000. (Briere, 2000).

Bromet, E.J., et al. "Growing up in the shadow of Chornobyl: Adolescents' risk perceptions and mental health," *Soc Psychiatry Psychiatr Epidemiol*, 46, 393–402, 2011. (Bromet, 2011).

Brooks, S.K., et al. "Social and occupational factors associated with psychological distress and disorder among disaster responders: a systemactic review," *BMC Psychology*, 4, 18, 2016. (Brooks, 2016).

Brown, M.R.G., et al. "Significant PTSD and other mental health effects present 18 months after the Fort McMurray wildfire: Findings from 3,070 Grades 7–12 students," *Frontiers in Psychiatry*, 10, 623, 2019. (Brown, 2019).

Buzunov, V.O., et al. "Psychosocial state of the adult evacuees and risk factors of negative change," *Probl Radiac Med Radiobiol*, 22, 79–96, 2017. (Buzunov, 2017).

Callen, J., McKenna, T. "Saving lives and preventing injuries from unjustified protective actions—methods for developing a comprehensive public protective action strategy for a severe NPP emergency," *Health Physics*, 114(5), 511–526, 2018. (Callen, 2018).

Cao, X., et al. "Psychological distress and health-related quality of life in relocated and nonrelocated older survivors after the 2008 Sichuan Earthquake," *Asian Nurs Res* (Korean Soc Nurs Sci), 9, 271–7, 2015. (Cao, 2015).

Caramanica, K., et al. "Posttraumatic stress disorder after Hurricane Sandy among persons exposed to the 9/11 disaster," *Int J Emerg Ment Health*, 17, 356–362, 2015. (Caramanica, 2015).

Carr, V.J., et al. "A sysnthesis of the findings from the Quake Impact Study: A two-year investigation of the psychosocial sequelae of the 1989 Newcastle earthquake," *Soc Psychiatry Psychiatr Epidemiol*, 32, 123–36, 1997. (Carr, 1997).

Castle, N.G., "Relocation of the elderly," *Med Care Res Rev*, 58, 291–333, 2001. (Castle, 2001).

Centers for Disease Control and Prevention (CDC). "Norovirus outbreak among evacuees from Hurricane Katrina—Houston, Texas, September 2005," *Morbidity and Mortality Weekly Report (MMWR)*, 54(40), 1016–1018. 2005. (CDC, 2005).

Chakraborty, J. "Proximity to extremely hazardous substances for people with disabilities: A case study in Houston, Texas," *Disabil Health*, 12, 121–125, 2019. (Chakraborty, 2019).

Chang, B.H., Hoaglin, D.C. "Meta-analysis of odds ratios: Current good practices," *Med Care*, 55, 328–335, 2017. (Chang, 2017).

Chen, Y.L., et al. “Risk factors for PTSD after Typhoon Morakot among elderly people in Taiwanese aboriginal communities,” *Int Psychogeriatr*, 23, 1686–91, 2011. (Chen, 2011).

Christensen, R.N. *Plane answers to complex questions: The theory of linear models*, Springer, New York, 1987. (Christensen, 1987).

Cuijpers, P. *Meta-analyses in mental health research: A practical guide*, Vrije Universiteit Amsterdam, 2016. (Cuijpers, 2016).

Davidow, A.L., et al. “Access to care in the wake of Hurricane Sandy, New Jersey, 2012,” *Disaster Med Public Health Prep*, 10, 485–91, 2016. (Davidow, 2016).

Davis, T.E. III, Grills-Taquechell, A.E., Ollendick, T.H. “The psychological impact from hurricane Katrina: Effects of displacement and trauma exposure on university students,” *Behav Ther*, 41, 340–9, 2010. (Davis, 2010).

Department of Health and Human Services (HHS). “2017–2022 health care preparedness and response capabilities,” Office of the Assistant Secretary for Preparedness and Response (ASPR), November 2016. (HHS, 2016).

DerSimonian, R., Laird, N. “Meta-analysis in clincial trials,” *Control Clin Trials*, 7, 177–88, 1986. (DerSimonian, 1986).

DeSalvo, K.B., et al. “Symptoms of posttraumatic stress disorder in a New Orleans workforce following Hurricane Katrina,” *J Urban Health*, 84, 142–52, 2007. (DeSalvo, 2007).

DiGrande, L., et al. “Posttraumatic stress symptoms, PTSD, and risk factors among lower Manhattan residents 2–3 years after the September 11, 2011 terrorist attacks,” *J Trauma Stress*, 21, 264–73, 2008. (DiGrande, 2008).

Dirkzwager, A.J., et al. “Risk factors for psychological and physical health problems after a man-made disaster. Prospective study,” *Br J Psychiatry*, 189, 144–9, 2006. (Dirkzwager, 2006a).

Dirkzwager, A.J., Kerssens, J.J., Yzermans, C.J. “Health problems in children and adolescents before and after a man-made disaster,” *J Am Acad Child Adolesc Psychiatry*, 45, 94–103, 2003. (Dirkzwager, 2006b).

Downey, E.L., Andress, K., Schultz, C.H. “External factors impacting hospital evacuations casued by Hurricane Rita: The role of situational awareness,” *Prehosp Disaster Med*, 28, 264–71, 2013. (Downey, 2013a).

Downey, E.L., Andress, K., Schultz, C.H. “Initial management of hospital evacuations caused by Hurricane Rita: A systematic investigation,” *Prehosp Disaster Med*, 28, 257–63, 2013. (Downey, 2013b).

Ebner, D.K., et al. “Lifestyle-related diseases following the evacuation after the Fukushima Daiichi nuclear power plant accident: A retrospective study of Kawauchi Village with long-term follow-up,” *BMJ Open*, 6, e011641, 2016. (Ebner, 2016).

Environmental Protection Agency (EPA). EPA-400/R-17/001, "PAG Manual: Protective Action Guides and planning guidance for radiological incidents," January 2017. (EPA, 2017).

Federal Emergency Management Agency (FEMA). "Communicating during and after a nuclear power plant incident," June 2013. (FEMA, 2013).

FEMA, "Tropical cyclones – watches, warnings, and track/intensity forecasts," FEMA Geospatial Resource Center, 2020. (FEMA, 2020).

Gallagher, J.J., et al. "Can burn centers evacuate in response to disasters?," *J Burn Care Res*, 27, 596–9, 2006. (Gallagher, 2006).

Gordon, H.S., Rosenthal, G.E., "Impact of interhospital transfers on outcomes in an academic medical center. Implications for profiling hospital quality," *Med Care*, 34, 295–309, 1996. (Gordon, 1996).

Goto, A., et al. "The Fukushima nuclear accident affected mothers' depression but not maternal confidence," *Asia Pac J Public Health*, 29, 139S–150S, 2017. (Goto, 2017).

Grievink, L., et al. "The importance of estimating selection bias on prevalence estimates shortly after a disaster," *Ann Epidemiol*, 16, 782–8, 2006. (Grievink, 2006).

Hasegawa, A., et al. "Emergency responses and health consequences after the Fukushima accident; Evacuation and relocation," *Clin Oncol (R Coll Radiol)*, 28, 237–44, 2016. (Hasegawa, 2016).

Hashimoto, S., et al. "Influence of post-disaster evacuation on incidence of metabolic syndrome," *J Atheroscler Thromb*, 24, 327–337, 2017. (Hashimoto, 2017).

Haverkort, J.J., et al. "Hospital evacuation: Exercise versus reality," *Injury*, 47, 2012–7, 2016. (Haverkort, 2016).

Hayashi, Y., et al. "The impact of evacuation on the incidence of chronic kidney disease after the Great East Japan Earthquake: The Fukushima Health Management Survey," *Clin Exp Nephrol*, 21, 995–1002, 2017. (Hayashi, 2017).

Hikichi, H., et al. "Residential relocation and obesity after a natural disaster: A natural experiment from the 2011 Japan Earthquake and Tsunami," *Sci Rep*, 9, 374, 2019. (Hikichi, 2019).

Hogg, D., et al. "The effects of relocation and level of affectedness on mood and anxiety symptom treatments after the 2011 Christchurch earthquake," *Soc Sci Med*, 152, 18–26, 2016. (Hogg, 2016).

Holle, C.L., Turnquist, M.A., Rudolph, J.L. "Safeguarding older adults with dementia, depression, and delirium in a temporary disaster shelter," *Nurs Forum*, 54, 157–164, 2019. (Holle, 2019).

Hori, A., et al. "Psychiatric outpatients after the 3.11 complex disasters in Fukushima, Japan," *Ann Glob Health*, 82, 798–805, 2016. (Hori, 2016).

Horikoshi, N., et al. “Residence-related factors and psychological distress among evacuees after the Fukushima Daiichi nuclear power plant accident: A cross-sectional study,” *BMC Psychiatry*, 16, 420, 2016. (Horikoshi, 2016).

Horikoshi, N., et al. “The characteristics of non-respondents and respondents of a mental health survey among evacuees in a disaster: The Fukushima Health Management Survey,” *Fukushima J Med Sci*, 63, 152–159, 2017. (Horikoshi, 2017).

Irwanto, F., Zulfa, H. “Posttraumatic stress disorder among Indonesian children 5 years after the tsunami,” *Southeast Asian J Trop Med Public Health*, 46, 918–23, 2015. (Irwanto, 2015).

Jenkins, J.L., et al. “Prevalence of unmet health care needs and description of health care-seeking behavior among displaced people after the 2007 California wildfiles,” *Disaster Med Public Health Prep*, 3, S24–8, 2009. (Jenkins, 2009).

Kar, N., et al. “Mental health consequences of the trauma of super-cyclone 1999 in Orissa,” *Indian J Psychiatry*, 46, 228–37, 2004. (Kar, 2004).

Kennedy, M.N., “Blood sugar & other hormones,” *Diabetes Education Online*, 2010. (Kennedy, 2010).

Kett, M.E., “Internally displaced peoples in Bosnia-Herzegovina: Impacts of long-term displacemnet on mental health and well-being,” *Med Confl Surviv*, 21, 199–215, 2005. (Kett, 2005).

Kilic, C., et al. “Predictors of psychological distress in survivors of the 1999 earthquakes in Turkey: Effects of relocations after the disaster, *Acta Psychiatr Scand*, 114, 194–202, 2006. (Kilic, 2006).

Kulkarni, P.A., et al. “Evacuations as a result of Hurricane Sandy: Analysis of the 2014 New Jersey Behavioral Risk Factor Survey,” *Disaster Med Public Health Prep*, 11, 720–728, 2017. (Kulkarni, 2017).

Kunii, Y., et al. “Severe psychological distress of evacuees in evacuation zone caused by the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey,” *PLoS One*, 11, e0158821, 2016. (Kunii, 2016).

La Greca, A.M., et al. “Before the storm: Stressors sssociated with the Hurricane Irma evacuation process for families,” *Disaster Med Public Health Prep*, 13, 63–73, 2019. (La Greca, 2019).

LaJoie, A.S., Sprang, G., McKinney, W.P. “Long-term effects of Hurricane Katrina on the psychological well-being of evacuees,” *Disasters*, 34, 1031–44, 2010. (LaJoie, 2010).

Lane, E., et al. “Health effects of coastal storms and flooding in urban areas: A review and vulnerability assessment,” *J Environ Public Health*, 2013, 913064, 2013. (Lane, 2013).

Lawrence, W.R., et al. “After the storm: Short-term and long-term health effects following Superstorm Sandy among the elderly,” *Disaster Med Public Health Prep*, 13, 28–32, 2019. (Lawrence, 2019).

Leppold, C., et al. “Sociodemographic patterning of long-term diabetes mellitus control following Japan’s 3.11 triple disaster: A retrospective cohort study,” *BMJ Open*, 6, e011455, 2016. (Leppold, 2016).

Litcher, L., et al. “School and neuropsychological performance of evacuated children in Kyiv 11 years after the Chornobyl disaster,” *J Child Psychol Psychiatry*, 41, 291–9, 2000. (Litcher, 2000).

Maeda, M., Oe, M. “Mental health consequences and social issues after the Fukushima disaster,” *Asia Pac J Public Health*, 29, 36S–46S, 2017. (Maeda, 2017).

Maeda, M., Oe, M., Suzuki, Y. “Psychological effects of the Fukushima disaster and current tasks,” *Journal of the National Institute of Public Health*, 67, 50–58, 2018. (Maeda, 2018).

Meixler, E. “Japan acknowledges the first radiation-linked death from the Fukushima nuclear disaster,” *Time*, Time USA, LLC. Last updated: September 5, 2018. Last visited: February 2021. https://time.com/5388178/japan-first-fukushima-radiation-death/ (Meixler, 2018).

Miller, J.J. “The Inverse of the Freeman-Tukey Double Arcsine Transformaiton,” *The American Statistician*, 32, 138, 1978. (Miller, 1978).

Milne, G. “Cyclone Tracy: I. Some consequences of the evacuation for adult victims,” *Australian Psychologist*, 12, 39–54, 1977. (Milne, 1977).

Miura, I., et al. “Perception of radiation risk as a predictor of mid-term mental health after a nuclear disaster: The Fukushima Health Management Survey,” *Int J Environ Res Public Health*, 14, 2017. (Miura, 2017).

Moosavi, S., et al. “Mental health effects in primary care patients 18 months after a major wildfire in For McMurray: Risk increased by social demographic issues, clincial antecedents, and degree of fire exposure,” *Front Psychiatry*, 10, 683, 2019. (Moosavi, 2019).

Morita, T., et al. “Demographic transition and factors associated with remaining in place after the 2011 Fukushima nuclear disaster and related evacuation orders,” *PLoS One*, 13, e0194134, 2018. (Morita, 2018).

Mortensen, K., Dreyfuss, Z. “How many walked through the door?: The effect of hurricane Katrina evacuees on Houston emergency departments,” *Med Care*, 46, 998–1001, 2008. (Mortensen, 2008).

Munro, A., et al. “Effect of evacuation and displacement on the association between flooding and mental health outcomes: A cross-sectional analysis of UK survey data,” *Lancet Planet Health*, 1, e134–e141, 2017. (Munro, 2017).

Murakami, M., Takebayashi, Y., Tsubokura, M. “Lower psychological distress levels among returnees compared with evacuees after the Fukushima nuclear accident,” *Tohoku J Exp Med*, 247, 13–17, 2019. (Murakami, 2019).

Nagai, M., et al. “Impact of evacuation on trends in the prevalence, treatment, and control of hypertension before and after a disaster,” *J Hypertens*, 36, 924–932, 2018. (Nagai, 2018).

Najarian, L.M., Majeed, M.H., Gasparyan, K. “Effect of relocation after a natural disaster in Armenia: 20-year follow-up,” *Asian J Psychiatr*, 29, 8–12, 2017. (Najarian, 2017).

Nakano, H., et al. “Associations of disaster-related and psychosocial factors with changes in smoking status after a disaster: A cross-sectional survey after the Great East Japan Earthquake,” *BMJ Open*, 8, e018943, 2018. (Nakano, 2018).

National Institutes of Health (NIH). *Post-traumatic stress disorder* [online]. Last updated: May 2019. Last visited: February 2021. https://www.nimh.nih.gov/health/topics/post-traumatic-stress-disorder-ptsd/index.shtml (NIH, 2019).

Neria, Y., Nandi, A., Galea, S. “Post-traumatic stress disorder following disasters: A systematic review,” *Psychol Med*, 38, 467–80, 2008. (Neria, 2008).

Nomura, S., et al. “Mortality risk amongst nursing home residents evacuated after the Fukushima nuclear accident: A retrospective cohort study,” *PLoS One*, 8, e60192, 2013. (Nomura, 2013).

Nomura, S., et al. “Post-nuclear disaster evacuation and survival amongst elederly people in Fukushima: A comparative analysis between evacuees and non-evacuees, *Prev Med*, 82, 77–82, 2016. (Nomura, 2016).

Norris, F.H., et al. “Postdisaster PTSD over four waves of a panel study of Mexico’s 1999 flood,” *J Trauma Stress*, 17, 283–92, 2004. (Norris, 2004).

Norris, F.H., Sherrieb, K., Galea, S. “Prevalence and consequences of disaster-related illness and injury from Hurricane Ike,” *Rehabil Psychol*, 55, 221–30, 2010. (Norris, 2010).

Nuclear Regualtory Commission (NRC). NUREG/CR-6953, Vol. I, SAND2007-5448P, “Review of NUREG-0654, Supplement 3, ‘Criteria for Protective Action Recommendations for Severe Accidents,’” December 2007. (NRC, 2007).

NRC. NUREG/CR-6953, Vol. II, SAND2007-4195P, “Review of NUREG-0654, Supplement 3, ‘Criteria for Protective Action Recommendations for Severe Accidents’ – Focus Groups and Telephone Survey,” October 2008. (NRC, 2008).

NRC. NUREG/CR-6953, Vol. III, SAND2010-2806P, “Review of NUREG-0654, Supplement 3, ‘Criteria for Protective Action Recommendations for Severe Accidents’ – Technical Basis for Protective Action Strategies,” August 2010. (NRC, 2010).

NRC. NUREG-0654/FEMA-REP-1, Rev. 1, Supplement 3, “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants – Guidance for Protective Action Strategies,” November 2011. (NRC, 2011).

Oe, M., et al. “Changes of posttraumatic stress responses in evacuated residents and their related factors,” *Asia Pac J Public Health*, 29, 182S–192S, 2017. (Oe, 2017).

Ohira, T., et al. “Evacuation and risk of hypertension after the Great East Japan Earthquake: The Fukushima Health Management Survey,” *Hypertension*, 68, 558–64, 2016. (Ohira, 2016a).

Ohira, T., et al. “Effect of evacuation on body weight after the Great East Japan Earthquake,” *Am J Prev Med*, 50, 553–560, 2016. (Ohira, 2016b).

Ohira, T., et al. “Changes in cardiovascular risk factors after the Great East Japan Earthquake, *Asia Pac J Public Health*, 29, 47S–55S, 2017. (Ohira, 2017).

Ollendick, D.G., Hoffmann, M. “Assessment of psychological reactions in disaster victims,” *Journal of Community Psychology*, 10, 157–167, 1982. (Ollendick, 1982).

Ozaki, A., et al. “Social isolation and cancer management—advanced rectal cancer with patient delay following the 2011 triple disaster in Fukushima, Japan: A case report,” *Journal of Medical Case Reports*, 11, 138–144, 2017. (Ozaki, 2017).

Parker, G. “Cyclone Tracy and Darwin evacuees: On the restoration of the species,” *Br J Psychiatry*, 130, 548–55, 1977. (Parker, 1977).

Pescosolido, B.A., et al. “A disease like any other? A decade of change in public reactions to schizophrenia, depression, and alcohol dependence,” Am J Psychiatry, 167, 1321–30, 2010. (Pescosolido, 2010).

Pfefferbaum, B., et al. “Effects of displacement in children exposed to disasters,” *Curr Psychiatry Rep*, 18, 71, 2016. (Pfefferbaum, 2016).

Pfefferbaum, B., et al. “A Skill Set for Supporting Displaced Children in Psychological Recovery After Disasters,” *Curr Psychiatry Rep*, 19, 60, 2017. (Pfefferbaum, 2017).

Quast, T., Gregory, S., Storch E.A. “Utilization of mental health services by children displaced by Hurricane Katrina,” *Psychiatr Serv*, 69, 580–586, 2018. (Quast, 2018).

Raudenbush, S.W., Bryk, A.S. “Empirical Bayes meta-analysis,” *Journal of Educational Statistics*,” 10, 75–98, 1985. (Raudenbush, 1985).

Rhodes, J., et al. “The impact of hurricane Katrina on the mental and physical health of low-income parents in New Orleans,” *Am J Orthopsychiatry*, 80, 237–247, 2010. (Rhodes, 2010).

Rusby, J.S., Tasker, F. “Long-term effects of the British evacuation of children during World War 2 on their adult mental health,” *Aging Ment Health*, 13, 391–404, 2009. (Rusby, 2009).

Saarela, J., Finnas, F. “Forced migration and mortality in the very long term: Did perestroika affect death rates also in Finland?,” *Demography*, 46, 575–87, 2009. (Saarela, 2009).

Saji, G. “A post accident safety analysis report of the Fukushima accident—future direction of evacuation: Lessons learned,” *Proceedings of the 21st International Conference on Nuclear Engineering*, *ICONE21*, July 29–August 2, 2013, Chengdu, China. (Saji, 2013).

Sakai, A., et al. “Life as an evacuee after the Fukushima Daiichi nuclear power plant accident is a cause of polycythemia: The Fukushima Health Management Survey,” *BMC Public Health*, 14, 1318, 2014. (Sakai, 2014).

Salcioglu, E., Ozden, S., Ari, F. “The role of relocation patterns and psychosocial stressors in posttraumatic stress disorder and depression among earthquake survivors,” *J Nerv Ment Dis*, 206, 19–26, 2018. (Salcioglu, 2018).

Sanders, S., Bowie, S.L., Bowie, Y.D. “Chapter 2 lessons learned on forced relocation of older adults,” *Journal of Gerontological Social Work*, 22–25, 2004. (Sanders, 2004).

Santavirta, T., et al. “Long term mental health outcomes of Finnish children evacuated to Swedish families during the second world war and their non-evacuated siblings: Cohort study,” *BMJ*, 350, g7753, 2015. (Santavirta, 2015).

Satoh, H., et al. “Evacuation after the Fukushima Daiichi nuclear power plant accident is a cause of diabetes: Results from the Fukushima Health Management Survey,” *J Diabetes Res*, 2015, 627390, 2015. (Satoh, 2015).

Satoh, H., et al. “Hypo-high-density lipoprotein cholesterolemia caused by evacuation after the Fukushima Daiichi nuclear power plant accident: Results from the Fukushima Health Management Survey,” *Intern Med*, 55, 1967–76, 2016. (Satoh, 2016a).

Satoh, H., et al. “Prevalence of renal dysfunction among evacuees and non-evacuees after the Great East Earthquake: Results from the Fukushima Health Management Survey,” *Intern Med*, 55, 2563–9, 2016. (Satoh, 2016b).

Sawa, M., et al. “Impact of the Great East Japan earthquake on caregiver burden: A cross-sectional study,” *Psychiatr Serv*, 64, 189–91, 2013. (Sawa, 2013).

Seide, S.E., Röver, C, Friede, T. “Likelihood-based random-effects meta-analysis with few studies: Empriical and simulation studies,” *BMC Medical Research Methodology*, 19, 16, 2019. (Seide, 2019).

Shimada, Y., et al. “Balancing the risk of the evacuation and sheltering-in-place options: A survival study following Japan’s 2011 Fukushima nuclear incident,” *BMJ Open*, 8, e021482, 2018. (Shimada, 2018).

Slone, M., Shoshani, A., Paltieli, T. “Psychological consequences of forced evacuation on children: Risk and protective factors,” *J Trauma Stress*, 22, 340–3, 2009. (Slone, 2009).

Smith, S.M., Vale, W.W. “The role of the hpothalamic-pituitary-adrenal axis in neuroendocrine responses to stress,” *Dialogues Clin Neurosci*, 8, 383–95, 2006. (Smith, 2006).

Stein, D.J., et al. “What is a mental/psychiatric disorder? From DSM-IV to DSM-V,” *Psychol Med*, 40, 1759–65, 2010. (Stein, 2010).

Takahashi, A., et al. “Effect of evacuation on liver function after the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey,” *J Epidemiol*, 27, 180–185, 2017. (Takahashi, 2017).

Takahashi, A., et al. “Effects of lifestyle on hepatobiliary enzyome abnormalities following the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey,” *Medicine* (Baltimore), 97, e12890, 2018. (Takahashi, 2018).

Takahashi, S., et al. “Association between relocation and changes in cardiometabolic risk factors: A longitudinal study in tsunami survivors of the 2011 Great East Japan Earthquake,” *BMJ Open*, 6, e011291, 2016. (Takahashi, 2016).

Tally, S., et al. “The impact of the San Diego wildfires on a general mental health population residing in evacuation areas,” *Adm Policy Ment Health*, 40, 348–54, 2013. (Tally, 2013).

Tanaka, R. “Prolonged living as a refugee from the area around a stricken nuclear power plant increases the risk of death,” *Prehosp Disaster Med*, 30, 425–30, 2015. (Tanaka, 2015).

Tanaka, R., Okawa, M., Ujike Y. “Predictors of hypertension in survivors of the Great East Japan Earthquake, 2011: A cross-sectional study,” *Prehosp Disaster Med*, 31, 17–26, 2016. (Tanaka, 2016).

Taormina, D.P., et al. “The Chornobyl accident and cognitive functioning: A follow-up study of infant evacuees at age 19 years,” *Psychol Med*, 38, 489–97, 2008. (Taormina, 2008).

Thienkrua, W., et al. “Symptoms of posttraumatic stress disorder and depression among children in tsunami-affected areas in sourthern Thailand,” *JAMA*, 296, 549–59, 2006. (Thienkrua, 2006).

Thomas, K.S., et al. “Effect of foced transitions on the most functionally impaired nursing home residents,” *J Am Geriatr Soc*, 60, 1895–900, 2012. (Thomas, 2012).

Thompson, D.J., et al. “Stress and cortisol in disaster evacuees: An exploratory study on associations with social protective factors,” *Appl Psychophysiol Biofeedback*, 40, 33–44, 2015. (Thompson, 2015).

Tomio, J., Sato, H., Mizumura, H. “Interruption of medication among outpatients with chronic conditions after a flood,” *Prehosp Disaster Med*, 25, 42–50, 2010. (Tomio, 2010).

Tsujiuchi, T., et al. “High prevalence of post-traumatic stress symptoms in relation to social factors in affected population one year after the Fukushima nuclear disaster,” *PLoS One*, 11, e0151807, 2016. (Tsujiuchi, 2016).

Tucker, P., et al. “Possible link of Interleukin-6 and Interleukin-2 with psychiatric diagnosis, ethnicity, disaster or BMI,” *Cytokine*, 96, 247–252, 2017. (Tucker, 2017).

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Report, Volume 1, “Levels and effects of radiation exposure due to the nuclear accident after the 2011 great east-Japan earthquake and tsunami. Scientific Annex A in Sources, Effects, and Risks of Ionizing Radiation,” UNSCEAR, 2013. (UNSCEAR, 2013).

Uscher-Pines, L. “Health effects of relocation following disaster: A systematic review of the literature,” *Disasters*, 33, 1–22, 2009. (Uscher-Pines, 2009).

van Griensven, F., et al. “Mental health problems among adults in tsunami-affected areas in southern Thailand,” *JAMA*, 296, 537–48, 2006. (van Griensven, 2006).

Verni, C. “A hospital system’s response to a hurricane offers lessons, including the need for mandatory interfacility drills,” *Health Aff* (Millwood), 31, 1814–21, 2012. (Verni, 2012).

Veroniki, A.A., et al. “Methods to estimate the between-study variance and its uncertainty in meta-analysis,” *Res Synth Methods*, 7, 55–79, 2016. (Veroniki, 2016).

Viechtbauer, W. “Conducting meta-analyses in R with the metafor package,” *Journal of Statistical Software*, 36, 2010. (Viechtbauer, 2010).

Waddington, I., et al. “J-value assessment of relocation measures following the nuclear power plant accidents at Chernobyl and Fukushima Daiichi,” *Process Safety and Environmental Protection*, 112, 16–49, 2017. (Waddington, 2017).

Wang, W., et al. “Prevalence of PTSD and depression among junior middle school students in a rural town far from the epicenter of the Wenchuan earthquake in China,” *PLoS One*, 7, e41665, 2012. (Wang, 2012).

Waugh, M.J., et al. “The long-term impact of war experiences and evacuation on people who were children during World War Two,” *Aging Ment Health*, 11, 168–174, 2007. (Waugh, 2007).

Wells, G., et al. “The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses,” Department of Epidemiology and Commuunity Medicine, University of Ottawa, 2014. (Wells, 2014).

Willoughby, M., et al. “Mortality in nursing homes following emergency evacuation: A systematic review,” *J Am Med Dir Assoc*, 18, 664–670, 2017. (Willoughby, 2017).

World Health Organization (WHO). *Radiation: Health consequences of the Fukushima nuclear accident*. Last updated: March 10, 2016. Last visited: February 2021. https://www.who.int/ionizing_radiation/a_e/fukushima/faqs-fukushima/en/ (WHO, 2016).

Yabe, H., et al. “Psychological distress after the Great East Japan Earthquake and Fukushima Daiichi Nuclear Power Plant accident: Results of a mental health and lifestyle survey through the Fukushima Health Management Survey in FY2011 and FY2012,” *Fukushima J Med Sci*, 60, 57–67, 2014. (Yabe, 2014).

Yao, B.C., et al. “Chronic stress: A critical risk factor for atheroschlerosis,” *J Int Med Res*, 47, 1429–1440, 2019. (Yao, 2019).

Yoshida, K., et al. “Psychological distress of residents in Kawauchi village, Fukushima Prefecture after the accident at Fukushima Daiichi Nuclear Power Station: The Fukushima Health Management Survey,” *PeerJ*, 4, e2353, 2016. (Yoshida, 2016).

Yzermans, C.J., et al. “Health problems of victims before and after disaster: A longitudinal study in general practice,” *Int J Epidemiol*, 34, 820–-6, 2005. (Yzermans, 2005).

APPENDIX A
LITERATURE REVIEW SEARCH METHODS

Table A-1 provides a complete list of search strings and search engines used during the literature review. The search strings are listed in the chronological order in which they were used. The unique search results given from each string (excluding repeats from past searches) are also reported, along with the number of papers saved for use in the analysis.

Table A-2 lists the publications included in the meta-analysis, with the primary author, title, year published, and a short summary. It also provides links to the full article.

Table A-1 List of Search Strings, Search Engines, and Results

Search String (chronological order)	Search Engine	Unique Results	Results Used
"disaster"+"evacuation"+"risk"	PubMed	376	33
"diabetes"+"disaster"+"evacuation"	PubMed	10	3
"disaster"+"evacuation"+"depression"	PubMed	16	3
"hurricane"+"risk"+"evacuation"	PubMed	6	1
"wildfire"+"risk"+"evacuation"	PubMed	4	1
"flood"+"risk"+"evacuation"	PubMed	6	1
"terrorist"+"risk"+"evacuation"	PubMed	4	0
"bomb"+"risk"+"evacuation"	PubMed	7	0
"volcano"+"risk"+"evacuation"	PubMed	1	0
"war"+"risk"+"evacuation"	PubMed	54	2
"chemical"+"risk"+"evacuation"	PubMed	30	0
evacuation associated accidents	PubMed	103	3
hurricane Rita evacuation	PubMed	20	1
"earthquake"+"risk"+"evacuation"	PubMed	5	0
Scopus search	Scopus	17	0
((Evacuee) NOT Fukushima) NOT Japan	Scopus	44	4
disaster evacuation relocation	Google Scholar	8	1
"Black Saturday" fire	PubMed	18	0
2004 hurricane displ*	PubMed	8	2
hurricane AND relocation	PubMed	22	1
earthquake AND relocation NOT Japan	PubMed	19	3
2007 England floods	PubMed	9	0
Wildfires AND (evacu* OR displaced OR relocate)	PubMed	22	0
"disaster"+"relocation"+"risk"	PubMed	24	1
"disaster"+"relocation"	PubMed	47	1
TITLE-ABS-KEY (“vehicle” AND “evacuation” AND “fatal*”) AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “re”))	Scopus	21	0
hospital AND morbidity AND evacuation AND disaster	PubMed	150	2
TITLE-ABS-KEY (“evacuation” AND “mortality” AND “disaster”)	Scopus	86	0
Unspecified citation reviews or Google search	n/a	73	19
	Totals	1,210	82

Table A-2 Publications in the Meta-analysis and Short Summaries

Author and Year	Title	Summary	Link
(Acierno, 2007)	Psychological sequelae resulting from the 2004 Florida hurricanes: Implications for postdisaster intervention	Examines the major risk factors associated with PTSD, generalized anxiety disorder, and major depressive episodes following the 2004 hurricane season.	Link
(Anderson, 2009)	Missed dialysis sessions and hospitalization in hemodialysis patients after Hurricane Katrina	Investigates the factors that contributed to missed dialysis sessions among New Orleans patients following Hurricane Katrina.	Link
(Behr, 2013)	Disparate health implications stemming from the propensity of elderly and medically fragile populations to shelter in place during severe storm events	Compares the likelihood for elderly households with various health needs to shelter in place rather than evacuate at the rate of the general population based on data from Hurricane Irene.	Link
(Belleville, 2019)	Post-traumatic stress among evacuees from the 2016 Fort McMurray wildfires: Exploration of psychological and sleep symptoms three months after the evacuation	Studies the psychological and sleep-related responses of evacuees exposed by different degrees to the 2016 Fort McMurray wildfires.	Link
(Bernard, 1996)	Comparing the hospitalizations of transfer and non-transfer patients in an academic medical center	Compares the characteristics of patients and their treatments between patients admitted directly to an academic medical center and patients who were transferred there.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Bromet, 2011)	Growing up in the shadow of Chornobyl: adolescents' risk perceptions and mental health	Discusses the results of a survey administered to adolescents who were infants or in utero at the time of the Chernobyl disaster and their mothers and compared them to unaffected families. The survey gauged the perceived and actual physical and psychological effects of the disaster.	Link
(Brown, 2019)	Significant PTSD and other mental health effects present 18 months after the Fort McMurray wildfire: Findings from 3,070 grades 7–12 students	Looks at the psychological effects of the 2016 Fort McMurray Wildfire on children between 7th and 12th grade.	Link
(Buzunov, 2017)	Psychosocial state of the adult evacuees and risk factors of negative change	Evacuees report stress factors caused by the Chernobyl disaster nearly 30 years after it occurred.	Link
(Cao, 2015)	Psychological distress and health-related quality of life in relocated and nonrelocated older survivors after the 2008 Sichuan Earthquake	Looks at the psychological effects of displaced and nondisplaced people following the 2008 Sichuan Earthquake and identifies predictors for negative effects.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Carr, 1997)	A synthesis of the findings from the Quake Impact Study: A two-year investigation of the psychosocial sequelae of the 1989 Newcastle earthquake	Examines the risk factors for psychological distress 2 years after the 1989 Newcastle earthquake.	Link
(CDC, 2005)	Norovirus outbreak among evacuees from hurricane Katrina—Houston, Texas, September 2005	Documents the outbreak of Norovirus at an evacuation shelter in Houston, Texas in the wake of Hurricane Katrina.	Link
(Davidow, 2016)	Access to care in the wake of Hurricane Sandy, New Jersey, 2012	Reports the results of a survey assessing New Jersey residents' access to medical care and medical needs after Hurricane Sandy and identifies risk factors for them.	Link
(Davis, 2010)	The psychological impact from Hurricane Katrina: Effects of displacement and trauma exposure on university students	Examines the disaster experience and psychological effects that Hurricane Katrina had on university students in the New Orleans area.	Link
(DeSalvo, 2007)	Symptoms of posttraumatic stress disorder in a New Orleans workforce following Hurricane Katrina	Studies the risk and predictors of symptoms of posttraumatic stress disorder in the New Orleans workforce following Hurricane Katrina.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Dirkzwager, 2006a)	Risk factors for psychological and physical health problems after a man-made disaster. Prospective study.	Studies the risk and predictors of symptoms of psychological distress and physical health problems after the Netherlands Fireworks Disaster.	Link
(Ebner, 2016)	Lifestyle-related diseases following the evacuation after the Fukushima Daiichi nuclear power plant accident: A retrospective study of Kawauchi Village with long-term follow-up.	Examines the changes in incidence of lifestyle-related diseases before and after the Fukushima accident for some of the first evacuees who returned to their homes.	Link
(Gallagher, 2006)	Can burn centers evacuate in response to disasters?	Reports the evacuation of a burn center in anticipation of Hurricane Gustav.	Link
(Gordon, 1996)	Impact of interhospital transfers on outcomes in an academic medical center. Implications for profiling hospital quality	Compares the mortality and other outcomes between transferred and nontransferred hospital patients outside of a disaster setting.	Link
(Goto, 2017)	The Fukushima nuclear accident affected mothers' depression but not maternal confidence	Looks at risk factors for depressive symptoms and maternal confidence among new mothers following the Fukushima disaster.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Grievink, 2006)	The importance of estimating selection bias on prevalence estimates shortly after a disaster	Researchers sent out a survey concerning the Netherlands Fireworks Disaster and compare the demographics of the subpopulation who responded with the entire affected population to estimate selection bias among survey responses.	Link
(Hashimoto, 2017)	Influence of post-disaster evacuation on incidence of metabolic syndrome	Looks at incidence and risk factors of metabolic syndrome among Fukushima evacuees and nonevacuees.	Link
(Haverkort, 2016)	Hospital evacuation: Exercise versus reality	Examines the history of practiced and actual evacuations at a hospital specifically designed to receive evacuees in the Netherlands.	Link
(Hayashi, 2017)	The impact of evacuation on the incidence of chronic kidney disease after the Great East Japan Earthquake: The Fukushima Health Management Survey	Studies the impact of evacuation on the incidence of chronic kidney disease following the Fukushima disaster.	Link
(Hogg, 2016)	The effects of relocation and level of affectedness on mood and anxiety symptom treatments after the 2011 Christchurch earthquake	Studies mood and anxiety symptoms related to movement among several affected subgroups following the 2011 Christchurch earthquake.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Horikoshi, 2017)	The characteristics of non-respondents and respondents of a mental health survey among evacuees in a disaster: The Fukushima Health Management Survey	Analyzes the lives of people who did not respond to a mental health survey to determine patterns in mental health among respondents and non-respondents.	Link
(Irwanto, 2015)	Posttraumatic Stress Disorder among Indonesian children 5 years after the tsunami	Looks at risk factors associated with PTSD among children 5 years after the Sumatra tsunami.	Link
(Jenkins, 2009)	Prevalence of unmet health care needs and description of health care-seeking behavior among displaced people after the 2007 California wildfires	Highlights the unmet medical needs, healthcare-seeking patterns, and prevalence of diseases among people displaced and staying in shelters following the 2007 California Wildfires.	Link
(Kar, 2004)	Mental health consequences of the trauma of super-cyclone 1999 in Orissa	Examines the psychiatric state of disaster survivors in the hardest hit areas of the 1999 Orissa super cyclone and identifies risk factors for adverse psychological effects.	Link
(Kilic, 2006)	Predictors of psychological distress in survivors of the 1999 earthquakes in Turkey: Effects of relocation after the disaster.	Looks at the psychological effects of relocation and associated predictors for various mental health problems following the 1999 Turkey earthquakes.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Kunii, 2016)	Severe psychological distress of evacuees in evacuation zone caused by the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey	Studies the various demographics and factors associated with psychological distress among Fukushima evacuees and nonevacuees.	Link
(LaJoie, 2010)	Long-term effects of Hurricane Katrina on the psychological well-being of evacuees	Studies the psychological health and well-being of long-term displaced people in Louisville, Kentucky following Hurricane Katrina.	Link
(Lawrence, 2019)	After the storm: Short-term and long-term health effects following Superstorm Sandy among the elderly	Examines the illnesses, injuries, and health care features among the elderly in affected counties at different timepoints after Hurricane Sandy.	Link
(Leppold, 2016)	Sociodemographic patterning of long-term diabetes mellitus control following Japan's 3.11 triple disaster: A retrospective cohort study	Looks at characteristics and predictors of patients who experienced a deterioration in glycemic control following the Fukushima disaster.	Link
(Litcher, 2000)	School and neuropsychological performance of evacuated children in Kyiv 11 years after the Chornobyl disaster	Compares the academic performance and psychological issues of children whose families were evacuated due to the Chernobyl nuclear power plant disaster when the children were infants or in utero with unaffected classmates.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Maeda, 2017)	Mental health consequences and social issues after the Fukushima disaster	A literature review concerning the worries and stigma about radiation changes and the changes in mental health for people affected by the Fukushima disaster.	Link
(Milne, 1977)	Cyclone Tracy: I. Some consequences of the evacuation for adult victims	Compares the "personal and social adaptation" between evacuated, relocated, and unevacuated individuals following Cyclone Tracy.	Link
(Miura, 2017)	Perception of radiation risk as a predictor of mid-term mental health after a nuclear disaster: The Fukushima Health Management Survey	Examines the association between perceived radiation risk (among other factors) and mental health at two different timepoints for people living in evacuation zones following the Fukushima disaster.	Link
(Moosavi, 2019)	Mental health effects in primary care patients 18 months after a major wildfire in Fort McMurray: Risk increased by social demographic issues, clinical antecedents, and degree of fire exposure	Estimates the prevalence and risk factors of mental health disorders among people visiting primary clinics in the months following the Fort McMurray Wildfire.	Link
(Mortensen, 2008)	How many walked through the door?: The effect of hurricane Katrina evacuees on Houston emergency departments	Reports the effect that displaced Hurricane Katrina victims had on emergency departments in Houston, Texas.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Munro, 2017)	Effect of evacuation and displacement on the association between flooding and mental health outcomes: A cross-sectional analysis of UK survey data	Studies the prevalence of symptoms for depression, anxiety, and PTSD among displaced and nondisplaced peoples following a series of floods in England.	Link
(Murakami, 2019)	Lower psychological distress levels among returnees compared with evacuees after the Fukushima nuclear accident	Compares the psychological distress levels between evacuated and relocated people almost 7 years after the Fukushima disaster.	Link
(Nagai, 2018)	Impact of evacuation on trends in the prevalence, treatment, and control of hypertension before and after a disaster	Studies the effect that the Fukushima disaster had on incidence rates of hypertension among displaced and nondisplaced people.	Link
(Najarian, 2017)	Effect of relocation after a natural disaster in Armenia: 20-year follow-up.	Compares the PTSD rates for evacuated, relocated, and unevacuated people 20 years after the 1988 Armenian earthquakes.	Link
(Nakano, 2018)	Associations of disaster-related and psychosocial factors with changes in smoking status after a disaster: A cross-sectional survey after the Great East Japan Earthquake	Studies whether the Fukushima disaster affected the smoking habits of displaced and nondisplaced individuals.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Nomura, 2013)	Mortality risk amongst nursing home residents evacuated after the Fukushima nuclear accident: A retrospective cohort study	Studies why different nursing homes had varying mortality rates during evacuations following the Fukushima disaster.	Link
(Nomura, 2016)	Post-nuclear disaster evacuation and survival amongst elderly people in Fukushima: A comparative analysis between evacuees and non-evacuees	Examines the evacuation-related mortality risks of elderly people evacuated from several elderly care facilities in the wake of the Fukushima disaster.	Link
(Norris, 2004)	Postdisaster PTSD over four waves of a panel study of Mexico's 1999 flood	Studies the incidence of PTSD and depressive symptoms in two areas that were hit by the 1999 Mexico floods and mudslides at four timepoints.	Link
(Norris, 2010)	Prevalence and consequences of disaster-related illness and injury from Hurricane Ike	Looks at the risk for injuries and illnesses of affected people in two Texas counties in the months after Hurricane Ike.	Link
(Oe, 2017)	Changes of posttraumatic stress responses in evacuated residents and their related factors	Examines the time pattern of PTSD among Fukushima victims over 3 years. Identifies risk factors for different observed patterns.	Link
(Ohira, 2016b)	Effect of evacuation on body weight After the Great East Japan Earthquake	Studies how body weight and obesity rates changed among displaced and nondisplaced people from following the Fukushima disaster.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Ohira, 2016a)	Evacuation and risk of hypertension after the Great East Japan Earthquake: The Fukushima Health Management Survey	Studies how evacuation affected the risk of hypertension and mean blood pressure following the Fukushima disaster.	Link
(Ohira, 2017)	Changes in cardiovascular risk factors after the Great East Japan Earthquake	Looks at the risk of cardiovascular and other diseases among displaced and nondisplaced individuals following the Fukushima disaster.	Link
(Ollendick, 1982)	Assessment of psychological reactions in disaster victims	Studies the psychological responses of families displaced to temporary housing following the 1978 Rochester, MN, flood.	Link
(Parker, 1977)	Cyclone Tracy and Darwin evacuees: On the restoration of the species	Studies the prevalence of psychological dysfunction and identifies stressors among evacuees at different timepoints following Cyclone Tracy.	Link
(Quast, 2018)	Utilization of mental health services by children displaced by Hurricane Katrina	Looks at mental health services and resource use among children with preexisting conditions displaced and not displaced by Hurricane Katrina.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Rhodes, 2010)	The impact of Hurricane Katrina on the mental and physical health of low-income parents in New Orleans	Studies how hurricane-related stressors and loss related to post-Katrina wellbeing and mental and physical health for low-income parents following Hurricane Katrina.	Link
(Rusby, 2009)	Long-term effects of the British evacuation of children during World War 2 on their adult mental health	Examines the long-term effects of being evacuated as a child in the United Kingdom during World War 2.	Link
(Sakai, 2014)	Life as an evacuee after the Fukushima Daiichi nuclear power plant accident is a cause of polycythemia: The Fukushima Health Management Survey	Looks at the changes in the risk and incidence of polycythemia among people affected by the Fukushima disaster and identifies risk factors for the disease.	Link
(Salcioglu, 2018)	The Role of relocation patterns and psychosocial stressors in posttraumatic stress disorder and depression among earthquake survivors	Studies how PTSD and depression symptoms differ for disaster victims based on where they relocated following the 2011 Van Earthquake.	Link
(Santavirta, 2015)	Long term mental health outcomes of Finnish children evacuated to Swedish families during the second world war and their non-evacuated siblings: Cohort study	Compares the risk of admission to a hospital for any type of psychiatric disorder between siblings who were or were not evacuated to foster families during World War 2.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Satoh, 2015)	Evacuation after the Fukushima Daiichi nuclear power plant accident is a cause of diabetes: Results from the Fukushima Health Management Survey	Looks at the glucose metabolism and risk factors for diabetes among people affected by the Fukushima disaster both before and after the event.	Link
(Satoh, 2016a)	Hypo-high-density lipoprotein cholesterolemia caused by evacuation after the Fukushima Daiichi nuclear power plant accident: Results from the Fukushima Health Management Survey	Looks at the incidence of hypo-high-density lipoprotein cholesterolemia among people affected by the Fukushima disaster and identifies several risk factors.	Link
(Sawa, 2013)	Impact of the Great East Japan earthquake on caregiver burden: A cross-sectional study	Studies the impact that evacuation had on caretakers for those with intellectual disabilities who were affected by the Fukushima disaster.	Link
(Shimada, 2018)	Balancing the risk of the evacuation and sheltering-in-place options: A survival study following Japan's 2011 Fukushima nuclear incident.	Examines evacuation-related mortality among patients in a hospital near the Fukushima nuclear power plant before and after the disaster.	Link
(Takahashi, 2016)	Association between relocation and changes in cardiometabolic risk factors: A longitudinal study in tsunami survivors of the 2011 Great East Japan Earthquake	Studies the changes in atherosclerotic cardiovascular risk factors because of relocation at different timepoints following the 2011 Japan earthquake and tsunami.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Takahashi, 2017)	Effect of evacuation on liver function after the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey	Looks at the changes in liver function according to drinking status among people affected by the Fukushima disaster.	Link
(Takahashi, 2018)	Effects of lifestyle on hepatobiliary enzyme abnormalities following the Fukushima Daiichi nuclear power plant accident: The Fukushima Health Management Survey	Compares hepatobiliary enzyme abnormalities and lifestyle differences between displaced and nondisplaced people following the Fukushima disaster.	Link
(Tally, 2013)	The impact of the San Diego wildfires on a general mental health population residing in evacuation areas	Looks at the impact that the 2007 California wildfires and subsequent evacuation events had on the mental health of people residing in evacuation areas.	Link
(Tanaka, 2016)	Predictors of hypertension in survivors of the Great East Japan Earthquake, 2011: A cross-sectional study	Studies the effect that taking antihypertensive drugs continually after the 2011 Japan earthquake and tsunami had on disaster victims staying in evacuation shelters.	Link
(Taormina, 2008)	The Chornobyl accident and cognitive functioning: A follow-up study of infant evacuees at age 19 years	Compares the academic and cognitive performance of 19-year-old students who were infants or in utero at the time of the Chernobyl nuclear disaster with control students.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Thienkrua, 2006)	Symptoms of posttraumatic stress disorder and depression among children in tsunami-affected areas in southern Thailand	Studies PTSD and depression rates in children affected by the 2004 Indonesia earthquake and tsunami and identifies risk factors and predictors for psychological morbidity.	Link
(Thomas, 2012)	Effect of forced transitions on the most functionally impaired nursing home residents	Compares the hospitalization and mortality rates of nursing home residents who were or were not evacuated due to Hurricane Gustav.	Link
(Thompson, 2015)	Stress and cortisol in disaster evacuees: An exploratory study on associations with social protective factors	Surveys evacuees immediately after the 2007 California wildfires for social protective factors and compares them with observed PTSD symptoms and cortisol levels.	Link
(Tomio, 2010)	Interruption of medication among outpatients with chronic conditions after a flood	Studies the effects of interruption of medications due to a disaster for outpatients affected by the 2006 Kagoshima flood.	Link
(Tsujiuchi, 2016)	High prevalence of post-traumatic stress symptoms in relation to social factors in affected population one year after the Fukushima nuclear disaster	Identifies PTSD and its social predictors for Fukushima disaster displaced individuals living in the Saitama prefecture 1 year after the disaster.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Tucker, 2017)	Possible link of Interleukin-6 and Interleukin-2 with psychiatric diagnosis, ethnicity, disaster or BMI	Examine the relationships of Interleukin-2 and Interleukin-6 with psychiatric diagnoses and other variables for Hurricane Katrina survivors who relocated to Oklahoma.	Link
(van Griensven, 2006)	Mental health problems among adults in tsunami-affected areas in southern Thailand	Looks at the incidence of mental health issues among adults affected by the 2004 Indonesia earthquake and tsunami at different timepoints.	Link
(Wang, 2012)	Prevalence of PTSD and depression among junior middle school students in a rural town far from the epicenter of the Wenchuan earthquake in China	Studies the PTSD and depression rates of junior middle school students in a rural town in China and compares the prevalence between different exposure groups.	Link
(Waugh, 2007)	The long-term impact of war experiences and evacuation on people who were children during World War Two	Studies the abuse, neglect, and psychological problems associated with the displacement of children evacuated from British cities who lived with strangers during World War 2.	Link

Table A-2 Publications in the Meta-analysis and Short Summaries (cont.)

Author and Year	Title	Summary	Link
(Yabe, 2014)	Psychological distress after the Great East Japan Earthquake and Fukushima Daiichi Nuclear Power Plant accident: Results of a mental health and lifestyle survey through the Fukushima Health Management Survey in FY2011 and FY2012	Studies the psychological risk and mental health of people of all ages affected by the Fukushima disaster soon after and 2 years after the disaster.	Link
(Yoshida, 2016)	Psychological distress of residents in Kawauchi village, Fukushima Prefecture after the accident at Fukushima Daiichi Nuclear Power Station: The Fukushima Health Management Survey	Looks at the psychological effects of evacuation and other disaster-related variables among a completely evacuated village following the Fukushima disaster.	Link
(Yzermans, 2005)	Health problems of victims before and after disaster: A longitudinal study in general practice	Examines the changes in health problems following the Netherlands Fireworks Disaster at two timepoints following the disaster for displaced and control populations.	Link

APPENDIX B
DATA USED IN META-ANALYSIS

Table B-1 lists the published studies included in the meta-analysis, with the primary author and year, publication title, event name, and the following data:

- Event type; e.g., hurricane, fire, flood, nuclear power plant emergency
- Time (in years) between the event and when the study was performed
- Population groups included in the study; i.e., displaced, nondisplaced, or both
- Health effect studied; e.g., PTSD, heart disease, mortality
- Data types available in the study; e.g., proportions, odds ratio
- Data sources for the study; e.g., standard test, self-reported, physician diagnosed

Table B-1 Data Used in Meta-analysis

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Acierno, 2007	Psychological sequelae resulting from the 2004 Florida Hurricanes: Implications for postdisaster intervention	2004 Florida Hurricanes	Hurricane	0.7	Displaced	PTSD	Proportions	Test
Anderson, 2009	Missed dialysis sessions and hospitalization in hemodialysis patients after Hurricane Katrina	Katrina	Hurricane	1.0	Displaced	General Health Effects	Proportions	Self-Reported
Anderson, 2009	Missed dialysis sessions and hospitalization in hemodialysis patients after Hurricane Katrina	Katrina	Hurricane	1.0	Displaced	General Health Effects	Proportions	Self-Reported
Behr, 2013	Disparate health implications stemming from the propensity of elderly and medically fragile populations to shelter in place during severe storm events	Irene	Hurricane	0.4	Nondisplaced and Displaced	Heart Disease	Odds Ratio	Self-Reported
Behr, 2013	Disparate health implications stemming from the propensity of elderly and medically fragile populations to shelter in place during severe storm events	Irene	Hurricane	0.4	Nondisplaced and Displaced	Diabetes	Odds Ratio	Self-Reported
Behr, 2013	Disparate health implications stemming from the propensity of elderly and medically fragile populations to shelter in place during severe storm events	Irene	Hurricane	0.4	Nondisplaced and Displaced	Healthcare Accessibility	Odds Ratio	Self-Reported

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Belleville, 2019	Post-traumatic stress among evacuees from the 2016 Fort McMurray wildfires: Exploration of psychological and sleep symptoms three months after the evacuation	Fort McMurray Wildfire	Fire	0.2	Displaced	Psychological Distress	Proportions	Test
Belleville, 2019	Post-traumatic stress among evacuees from the 2016 Fort McMurray wildfires: Exploration of psychological and sleep symptoms three months after the evacuation	Fort McMurray Wildfire	Fire	0.2	Displaced	Sleep Problems	Proportions	Test
Belleville, 2019	Post-traumatic stress among evacuees from the 2016 Fort McMurray wildfires: Exploration of psychological and sleep symptoms three months after the evacuation	Fort McMurray Wildfire	Fire	0.2	Displaced	Depression	Proportions	Test
Belleville, 2019	Post-traumatic stress among evacuees from the 2016 Fort McMurray wildfires: Exploration of psychological and sleep symptoms three months after the evacuation	Fort McMurray Wildfire	Fire	0.2	Displaced	Anxiety	Proportions	Test
Belleville, 2019	Post-traumatic stress among evacuees from the 2016 Fort McMurray wildfires: Exploration of psychological and sleep symptoms three months after the evacuation	Fort McMurray Wildfire	Fire	0.2	Displaced	Substance Abuse	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Belleville, 2019	Post-traumatic stress among evacuees from the 2016 Fort McMurray wildfires: Exploration of psychological and sleep symptoms three months after the evacuation	Fort McMurray Wildfire	Fire	0.2	Displaced	PTSD	Proportions	Test
Bernard, 1996	Comparing the hospitalizations of transfer and non-transfer patients in an academic medical center.		Relocation Event		Nondisplaced and Displaced	Mortality	Proportions	Physician
Bromet, 2011	Growing up in the shadow of Chornobyl: adolescents' risk perceptions and mental health	Chernobyl	Nuclear Power Plant	19.0	Displaced	General Health Effects	Proportions	Self-Reported
Brown, 2019	Significant PTSD and other mental health effects present 18 months after the Fort McMurray wildfire: Findings from 3,070 grades 7–12 students	Fort McMurray Wildfire	Fire	1.5	Displaced	Psychological Distress	Proportions	Test
Brown, 2019	Significant PTSD and other mental health effects present 18 months after the Fort McMurray wildfire: Findings from 3,070 grades 7–12 students	Fort McMurray Wildfire	Fire	1.5	Displaced	PTSD	Proportions	Test
Brown, 2019	Significant PTSD and other mental health effects present 18 months after the Fort McMurray wildfire: Findings from 3,070 grades 7–12 students	Fort McMurray Wildfire	Fire	1.5	Displaced	Depression	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Brown, 2019	Significant PTSD and other mental health effects present 18 months after the Fort McMurray wildfire: Findings from 3,070 grades 7–12 students	Fort McMurray Wildfire	Fire	1.5	Displaced	Anxiety	Proportions	Test
Brown, 2019	Significant PTSD and other mental health effects present 18 months after the Fort McMurray wildfire: Findings from 3,070 grades 7–12 students	Fort McMurray Wildfire	Fire	1.5	Displaced	Substance Abuse	Proportions	Test
Buzunov, 2017	Psychosocial state of the adult evacuees and risk factors of negative change	Chernobyl	Nuclear Power Plant	28.0	Displaced	General Health Effects	Proportions	Self-Reported
Cao, 2015	Psychological distress and health-related quality of life in relocated and nonrelocated older survivors after the 2008 Sichuan earthquake	2008 Sichuan Earthquake	Earthquake	5.0	Displaced	Psychological Distress	Proportions	Test
Carr, 1997	A synthesis of the findings from the Quake Impact Study: a two-year investigation of the psychosocial sequelae of the 1989 Newcastle earthquake	1989 Newcastle Earthquake	Earthquake	2.0	Displaced	PTSD	Odds Ratio	Test
CDC, 2005	Norovirus outbreak among evacuees from hurricane Katrina--Houston, Texas, September 2005	Katrina	Hurricane	0.1	Displaced	General Health Effects	Proportions	Physician
Davidow, 2016	Access to care in the wake of Hurricane Sandy, New Jersey, 2012	Sandy	Hurricane	2.0	Nondisplaced and Displaced	Healthcare Accessibility	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Davis, 2010	The Psychological impact from Hurricane Katrina: Effects of displacement and trauma exposure on university students	Katrina	Hurricane	0.3	Nondisplaced and Displaced	Depression	Odds Ratio	Test
Davis, 2010	The Psychological impact from Hurricane Katrina: Effects of displacement and trauma exposure on university students	Katrina	Hurricane	0.3	Nondisplaced and Displaced	Anxiety	Odds Ratio	Test
Davis, 2010	The Psychological impact from Hurricane Katrina: Effects of displacement and trauma exposure on university students	Katrina	Hurricane	0.3	Nondisplaced and Displaced	PTSD	Odds Ratio	Test
DeSalvo, 2007	Symptoms of posttraumatic stress disorder in a New Orleans workforce following Hurricane Katrina	Katrina	Hurricane	0.5	Displaced	PTSD	Odds Ratio	Test
Dirkzwager, 2006a	Risk factors for psychological and physical health problems after a man-made disaster	Netherlands Fireworks Disaster	Explosion	0.1	Displaced	Sleep Problems	Odds Ratio	Physician
Dirkzwager, 2006a	Risk factors for psychological and physical health problems after a man-made disaster	Netherlands Fireworks Disaster	Explosion	0.1	Displaced	General Health Effects	Odds Ratio	Physician
Dirkzwager, 2006a	Risk factors for psychological and physical health problems after a man-made disaster	Netherlands Fireworks Disaster	Explosion	0.1	Displaced	Respiratory	Odds Ratio	Physician
Ebner, 2016	Lifestyle-related diseases following the evacuation after the Fukushima Daiichi nuclear power plant accident: a retrospective study of Kawauchi Village with long-term follow-up.	Fukushima	Nuclear Power Plant	1.0	Displaced	Diabetes	Odds Ratio	Physician

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Ebner, 2016	Lifestyle-related diseases following the evacuation after the Fukushima Daiichi nuclear power plant accident: a retrospective study of Kawauchi Village with long-term follow-up.	Fukushima	Nuclear Power Plant	1.0	Displaced	Weight Problems	Odds Ratio	Physician
Ebner, 2016	Lifestyle-related diseases following the evacuation after the Fukushima Daiichi nuclear power plant accident: a retrospective study of Kawauchi Village with long-term follow-up.	Fukushima	Nuclear Power Plant	1.0	Displaced	Heart Disease	Odds Ratio	Physician
Ebner, 2016	Lifestyle-related diseases following the evacuation after the Fukushima Daiichi nuclear power plant accident: a retrospective study of Kawauchi Village with long-term follow-up.	Fukushima	Nuclear Power Plant	1.0	Displaced	General Health Effects	Odds Ratio	Physician
Gallagher, 2016	Can burn centers evacuate in response to disasters?	Katrina	Hurricane	0.0	Displaced	Mortality	Proportions	Physician
Gordon, 1996	Impact of interhospital transfers on outcomes in an academic medical center: Implications for profiling hospital quality	n/a	Relocation Event	0.0	Nondisplaced and Displaced	Mortality	Odds Ratio	Physician
Goto, 2017	The Fukushima nuclear accident affected mothers' depression but not maternal confidence	Fukushima	Nuclear Power Plant	1.0	Displaced	Psychological Distress	Proportions	Self-Reported
Goto, 2017	The Fukushima nuclear accident affected mothers' depression but not maternal confidence	Fukushima	Nuclear Power Plant	1.0	Displaced	Depression	Proportions	Self-Reported

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Grievink, 2006	The importance of estimating selection bias on prevalence estimates shortly after a disaster	Netherlands Fireworks Disaster	Explosion	0.1	Nondisplaced and Displaced	Other	Odds Ratio	Self-Reported
Hashimoto, 2017	Influence of post-disaster evacuation on incidence of metabolic syndrome	Fukushima	Nuclear Power Plant	2.0	Nondisplaced and Displaced	Substance Abuse	Odds Ratio	Physician
Hashimoto, 2017	Influence of post-disaster evacuation on incidence of metabolic syndrome	Fukushima	Nuclear Power Plant	2.0	Nondisplaced and Displaced	Weight Problems	Odds Ratio	Physician
Hashimoto, 2017	Influence of post-disaster evacuation on incidence of metabolic syndrome	Fukushima	Nuclear Power Plant	2.0	Nondisplaced and Displaced	General Health Effects	Odds Ratio	Physician
Haverkort, 2016	Hospital evacuation: exercise versus reality.	n/a	Flood	1.0	Displaced	Mortality	Proportions	Physician
Hayashi, 2017	The impact of evacuation on the incidence of chronic kidney disease after the Great East Japan Earthquake: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	2.5	Nondisplaced and Displaced	General Health Effects	Odds Ratio	Physician
Hogg, 2016	The effects of relocation and level of affectedness on mood and anxiety symptom treatments after the 2011 Christchurch earthquake	2011 Christchurch Earthquake	Earthquake	1.0	Nondisplaced and Displaced	Psychological Distress	Odds Ratio	Physician
Horikoshi, 2017	The characteristics of non-respondents and respondents of a mental health survey among evacuees in a disaster: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	4.0	Displaced	Other	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Horikoshi, 2017	The characteristics of non-respondents and respondents of a mental health survey among evacuees in a disaster: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	4.0	Displaced	PTSD	Proportions	Test
Horikoshi, 2017	The characteristics of non-respondents and respondents of a mental health survey among evacuees in a disaster: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	4.0	Displaced	Psychological Distress	Proportions	Test
Irwanto, 2015	Posttraumatic stress disorder among Indonesian children 5 Years after the tsunami	2004 Indian Ocean Earthquake and Tsunami	Earthquake and Tsunami	5.0	Displaced	PTSD	Proportions	Test
Jenkins, 2009	Prevalence of unmet health care needs and description of health care-seeking behavior among displaced people after the 2007 California wildfires	2007 California Wildfires	Fire	0.0	Displaced	Healthcare Accessibility	Proportions	Self-Reported
Jenkins, 2009	Prevalence of unmet health care needs and description of health care-seeking behavior among displaced people after the 2007 California wildfires	2007 California Wildfires	Fire	0.0	Displaced	Respiratory	Proportions	Self-Reported
Jenkins, 2009	Prevalence of unmet health care needs and description of health care-seeking behavior among displaced people after the 2007 California wildfires	2007 California Wildfires	Fire	0.0	Displaced	General Health Effects	Proportions	Self-Reported

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Jenkins, 2009	Prevalence of unmet health care needs and description of health care-seeking behavior among displaced people after the 2007 California wildfires	2007 California Wildfires	Fire	0.0	Displaced	Heart Disease	Proportions	Self-Reported
Kar, 2004	Mental health Consequences of the trauma of super-cyclone 1999 in Orissa, people living in the worst hit (high exposure) areas	Orissa Super Cyclone	Cyclone	0.8	Nondisplaced and Displaced	Psychological Distress	Odds Ratio	Test
Kar, 2004	Mental health Consequences of the trauma of super-cyclone 1999 in Orissa, people living in the worst hit (high exposure) areas	Orissa Super Cyclone	Cyclone	0.8	Nondisplaced and Displaced	Anxiety	Odds Ratio	Test
Kar, 2004	Mental health Consequences of the trauma of super-cyclone 1999 in Orissa, people living in the worst hit (high exposure) areas	Orissa Super Cyclone	Cyclone	0.8	Nondisplaced and Displaced	Depression	Odds Ratio	Test
Kar, 2004	Mental health Consequences of the trauma of super-cyclone 1999 in Orissa, people living in the worst hit (high exposure) areas	Orissa Super Cyclone	Cyclone	0.8	Nondisplaced and Displaced	PTSD	Odds Ratio	Test
Kilic, 2006	Predictors of psychological distress in survivors of the 1999 earthquakes in Turkey: Effects of relocation after the disaster	Turkey Earthquakes	Earthquake	4.0	Nondisplaced and Displaced	Psychological Distress	Odds Ratio	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Event	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Kilic, 2006	Predictors of psychological distress in survivors of the 1999 earthquakes in Turkey: Effects of relocation after the disaster	Turkey Earthquakes	Earthquake	4.0	Nondisplaced and Displaced	PTSD	Odds Ratio	Test
Kilic, 2006	Predictors of psychological distress in survivors of the 1999 earthquakes in Turkey: Effects of relocation after the disaster	Turkey Earthquakes	Earthquake	4.0	Nondisplaced and Displaced	Other	Odds Ratio	Test
Kilic, 2006	Predictors of psychological distress in survivors of the 1999 earthquakes in Turkey: Effects of relocation after the disaster	Turkey Earthquakes	Earthquake	4.0	Nondisplaced and Displaced	Depression	Odds Ratio	Test
Kunii, 2016	Severe psychological distress of evacuees in evacuation zone caused by the Fukushima Daiichi Nuclear Power Plant Accident: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	1.0	Displaced	Psychological Distress	Proportions	Test
LaJoie, 2010	Long-term effects of Hurricane Katrina on the psychological well-being of evacuees	Katrina	Hurricane	1.0	Displaced	PTSD	Proportions	Test
Lawrence, 2019	After the Storm: Short-term and long-term health effects following Superstorm Sandy among the elderly	Sandy	Hurricane	0.1	Displaced	Heart Disease	Odds Ratio	Physician
Lawrence, 2019	After the Storm: Short-term and long-term health effects following Superstorm Sandy among the elderly	Sandy	Hurricane	0.1	Displaced	Respiratory	Odds Ratio	Physician

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Lawrence, 2019	After the Storm: Short-term and long-term health effects following Superstorm Sandy among the elderly	Sandy	Hurricane	0.1	Displaced	General Health Effects	Odds Ratio	Physician
Leppold, 2016	Sociodemographic patterning of long-term diabetes mellitus control following Japan's 3.11 triple disaster: a retrospective cohort study	Fukushima	Nuclear Power Plant	1.0	Nondisplaced and Displaced	Diabetes	Odds Ratio	Physician
Litcher, 2000	School and neuropsychological performance of evacuated children in Kyiv 11 years after the Chornobyl disaster	Chernobyl	Nuclear Power Plant	11.0	Displaced	Other	Proportions	Self-Reported
Litcher, 2000	School and neuropsychological performance of evacuated children in Kyiv 11 years after the Chornobyl disaster	Chernobyl	Nuclear Power Plant	11.0	Displaced	Anxiety	Proportions	Self-Reported
Maeda, 2017	Mental health consequences and social issues after the Fukushima disaster	Fukushima	Nuclear Power Plant	0.3	Displaced	Psychological Distress	Proportions	Test
Maeda, 2017	Mental health consequences and social issues after the Fukushima disaster	Fukushima	Nuclear Power Plant	0.3	Displaced	PTSD	Proportions	Test
Milne, 1977	Cyclone Tracy: I Some consequences of the evacuation for adult victims	Tracy	Cyclone	0.8	Nondisplaced and Displaced	Depression	Odds Ratio	Self-Reported
Milne, 1977	Cyclone Tracy: I Some consequences of the evacuation for adult victims	Tracy	Cyclone	0.8	Nondisplaced and Displaced	Other	Odds Ratio	Self-Reported

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Milne, 1977	Cyclone Tracy: I Some consequences of the evacuation for adult victims	Tracy	Cyclone	0.8	Nondisplaced and Displaced	Substance Abuse	Odds Ratio	Self-Reported
Milne, 1977	Cyclone Tracy: I Some consequences of the evacuation for adult victims	Tracy	Cyclone	0.8	Nondisplaced and Displaced	Weight Problems	Odds Ratio	Self-Reported
Milne, 1977	Cyclone Tracy: I Some consequences of the evacuation for adult victims	Tracy	Cyclone	0.8	Nondisplaced and Displaced	General Health Effects	Odds Ratio	Self-Reported
Milne, 1977	Cyclone Tracy: I Some consequences of the evacuation for adult victims	Tracy	Cyclone	0.8	Nondisplaced and Displaced	Psychological Distress	Odds Ratio	Self-Reported
Miura, 2017	Perception of radiation risk as a predictor of mid-term mental health after a nuclear disaster: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	1.0	Displaced	PTSD	Proportions	Test
Moosavi, 2019	Mental health effects in primary care patients 18 months after a major wildfire in Fort McMurray: Risk increased by social demographic issues, clinical antecedents, and degree of fire exposure	Fort McMurray Wildfire	Fire	1.5	Displaced	PTSD	Proportions	Test
Moosavi, 2019	Mental health effects in primary care patients 18 months after a major wildfire in Fort McMurray: Risk increased by social demographic issues, clinical antecedents, and degree of fire exposure	Fort McMurray Wildfire	Fire	1.5	Displaced	Anxiety	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Moosavi, 2019	Mental health effects in primary care patients 18 months after a major wildfire in Fort McMurray: Risk increased by social demographic issues, clinical antecedents, and degree of fire exposure	Fort McMurray Wildfire	Fire	1.5	Displaced	Depression	Proportions	Test
Mortensen, 2008	How many walked through the door?: The effect of hurricane Katrina evacuees on Houston emergency departments	Katrina	Hurricane	0.3	Displaced	Respiratory	Proportions	Physician
Mortensen, 2008	How many walked through the door?: The effect of hurricane Katrina evacuees on Houston emergency departments	Katrina	Hurricane	0.3	Displaced	General Health Effects	Proportions	Physician
Mortensen, 2008	How many walked through the door?: The effect of hurricane Katrina evacuees on Houston emergency departments	Katrina	Hurricane	0.3	Displaced	Other	Proportions	Physician
Munro, 2017	Effect of evacuation and displacement on the association between flooding and mental health outcomes: a cross-sectional analysis of UK survey data	Winter 2013–14 Floods	Flood	1.0	Nondisplaced and Displaced	PTSD	Odds Ratio	Test
Munro, 2017	Effect of evacuation and displacement on the association between flooding and mental health outcomes: a cross-sectional analysis of UK survey data	Winter 2013–14 Floods	Flood	1.0	Nondisplaced and Displaced	Anxiety	Odds Ratio	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Munro, 2017	Effect of evacuation and displacement on the association between flooding and mental health outcomes: a cross-sectional analysis of UK survey data	Winter 2013–14 Floods	Flood	1.0	Nondisplaced and Displaced	Depression	Odds Ratio	Test
Murakami, 2019	Lower psychological distress levels among returnees compared with evacuees after the Fukushima nuclear accident	Fukushima	Nuclear Power Plant	7.0	Displaced	Psychological Distress	Proportions	Test
Nagai, 2018	Impact of evacuation on trends in the prevalence, treatment, and control of hypertension before and after a disaster	Fukushima	Nuclear Power Plant	3.0	Displaced	Heart Disease	Odds Ratio	Physician
Najarian, 2017	Effect of relocation after a natural disaster in Armenia: 20-year follow-up	Armenian Earthquake	Earthquake	20.0	Displaced	PTSD	Odds Ratio	Test
Nakano, 2018	Associations of disaster-related and psychosocial factors with changes in smoking status after a disaster: a cross-sectional survey after the Great East Japan Earthquake	Fukushima	Nuclear Power Plant	0.8	Nondisplaced and Displaced	Substance Abuse	Odds Ratio	Self-Reported
Nomura, 2013	Mortality risk amongst nursing home residents evacuated after the Fukushima nuclear accident: a retrospective cohort study	Fukushima	Nuclear Power Plant	0.8	Nondisplaced and Displaced	Mortality	Odds Ratio	Self-Reported
Nomura, 2016	Post-nuclear disaster evacuation and survival amongst elderly people in Fukushima: A comparative analysis between evacuees and non-evacuees.	Fukushima	Nuclear Power Plant	2.0	Nondisplaced and Displaced	Mortality	Odds Ratio	Physician

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Norris, 2004	Postdisaster PTSD over four waves of a panel study of Mexico's 1999 flood, adults from two different areas hit by the disasters	Mexico Floods and Mudslides	Flood	0.5	Displaced	PTSD	Proportions	Test
Norris, 2010	Prevalence and consequences of disaster-related illness and injury from Hurricane Ike	Ike	Hurricane	0.3	Displaced	PTSD	Proportions	Test
Oe, 2017	Changes of posttraumatic stress responses in evacuated residents and their related factors	Fukushima	Nuclear Power Plant	0.8	Displaced	PTSD	Proportions	Test
Ohira, 2016a	Evacuation and risk of hypertension after the Great East Japan Earthquake: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	2.0	Displaced	Sleep Problems	Odds Ratio	Physician
Ohira, 2016a	Evacuation and risk of hypertension after the Great East Japan Earthquake: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	2.0	Nondisplaced and Displaced	Substance Abuse	Odds Ratio	Physician
Ohira, 2016a	Evacuation and risk of hypertension after the Great East Japan Earthquake: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	2.0	Nondisplaced and Displaced	Heart Disease	Odds Ratio	Physician
Ohira, 2016b	Effect of evacuation on body weight after the Great East Japan Earthquake	Fukushima	Nuclear Power Plant	2.0	Nondisplaced and Displaced	Weight Problems	Odds Ratio	Physician
Ohira, 2017	Changes in cardiovascular risk factors after the Great East Japan Earthquake	Fukushima	Nuclear Power Plant	2.0	Displaced	Diabetes	Odds Ratio	Physician

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Ohira, 2017	Changes in cardiovascular risk factors after the Great East Japan Earthquake	Fukushima	Nuclear Power Plant	2.0	Displaced	General Health Effects	Odds Ratio	Physician
Ollendick, 1982	Assessment of psychological reactions in disaster victims, flood victims from Rochester, Minnesota	Rochester Flood	Flood	0.7	Displaced	Psychological Distress	Proportions	Self-Reported
Parker, 1977	Cyclone Tracy and Darwin evacuees: on the restoration of the species	Cyclone Tracy	Cyclone	0.0	Nondisplaced and Displaced	Psychological Distress	Odds Ratio	Test
Quast, 2018	Utilization of mental health services by children displaced by Hurricane Katrina	Katrina	Hurricane	1.0	Displaced	Depression	Odds Ratio	Physician
Quast, 2018	Utilization of mental health services by children displaced by Hurricane Katrina	Katrina	Hurricane	1.0	Displaced	Psychological Distress	Odds Ratio	Physician
Quast, 2018	Utilization of mental health services by children displaced by Hurricane Katrina	Katrina	Hurricane	1.0	Nondisplaced and Displaced	PTSD	Odds Ratio	Physician
Rhodes, 2010	The Impact of hurricane Katrina on the mental and physical health of low-income parents in New Orleans	Katrina	Hurricane	1.5	Displaced	PTSD	Proportions	Test
Rhodes, 2010	The Impact of hurricane Katrina on the mental and physical health of low-income parents in New Orleans	Katrina	Hurricane	1.5	Displaced	Psychological Distress	Proportions	Test
Rusby, 2009	Long-term effects of the British evacuation of children during World War 2 on their adult mental health	WW2	War	58.0	Displaced	Depression	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Rusby, 2009	Long-term effects of the British evacuation of children during World War 2 on their adult mental health	WW2	War	58.0	Displaced	Anxiety	Proportions	Test
Sakai, 2014	Life as an evacuee after the Fukushima Daiichi nuclear power plant accident is a cause of polycythemia: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	1.6	Nondisplaced and Displaced	Heart Disease	Odds Ratio	Physician
Sakai, 2014	Life as an evacuee after the Fukushima Daiichi nuclear power plant accident is a cause of polycythemia: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	1.6	Nondisplaced and Displaced	Weight Problems	Odds Ratio	Physician
Sakai, 2014	Life as an evacuee after the Fukushima Daiichi nuclear power plant accident is a cause of polycythemia: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	1.6	Nondisplaced and Displaced	Substance Abuse	Odds Ratio	Physician
Sakai, 2014	Life as an evacuee after the Fukushima Daiichi nuclear power plant accident is a cause of polycythemia: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	1.6	Nondisplaced and Displaced	Diabetes	Odds Ratio	Physician
Salcioglu, 2018	The role of relocation patterns and psychosocial stressors in posttraumatic stress disorder and depression among earthquake survivors	2011 Van Earthquake	Earthquake	1.4	Displaced	PTSD	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Salcioglu, 2018	The role of relocation patterns and psychosocial stressors in posttraumatic stress disorder and depression among earthquake survivors	2011 Van Earthquake	Earthquake	1.4	Displaced	Depression	Proportions	Test
Santavirta, 2015	Long term mental health outcomes of Finnish children evacuated to Swedish families during the second world war and their non-evacuated siblings: Cohort study, adults who as children were evacuated to Swedish foster families during WW2 and their non-evacuated siblings	WW2	War	47.0	Displaced	Psychological Distress	Odds Ratio	Physician
Santavirta, 2015	Long term mental health outcomes of Finnish children evacuated to Swedish families during the second world war and their non-evacuated siblings: Cohort study, adults who as children were evacuated to Swedish foster families during WW2 and their non-evacuated siblings	WW2	War	47.0	Displaced	Substance Abuse	Odds Ratio	Physician
Satoh, 2015	Evacuation after the Fukushima Daiichi Nuclear Power Plant accident is a cause of diabetes: Results from the Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	1.5	Displaced	Diabetes	Odds Ratio	Physician

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Satoh, 2016a	Hypo-high-density lipoprotein cholesterolemia caused by evacuation after the Fukushima Daiichi Nuclear Power Plant accident: Results from the Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	1.6	Nondisplaced and Displaced	General Health Effects	Odds Ratio	Physician
Sawa, 2013	Impact of the Great East Japan Earthquake on caregiver burden: A cross-sectional study	Fukushima	Nuclear Power Plant	0.6	Nondisplaced and Displaced	Psychological Distress	Odds Ratio	Test
Shimada, 2018	Balancing the risk of the evacuation and sheltering-in-place options: A survival study following Japan's 2011 Fukushima nuclear incident	Fukushima	Nuclear Power Plant	5.0	Displaced	Mortality	Odds Ratio	Physician
Takahashi, 2016	Association between relocation and changes in cardiometabolic risk factors: A longitudinal study in tsunami survivors of the 2011 Great East Japan Earthquake	Great East Japan Earthquake	Earthquake	0.7	Nondisplaced and Displaced	Sleep Problems	Odds Ratio	Self-Reported
Takahashi, 2016	Association between relocation and changes in cardiometabolic risk factors: A longitudinal study in tsunami survivors of the 2011 Great East Japan Earthquake	Great East Japan Earthquake	Earthquake	0.7	Nondisplaced and Displaced	Heart Disease	Odds Ratio	Self-Reported

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Takahashi, 2016	Association between relocation and changes in cardiometabolic risk factors: A longitudinal study in tsunami survivors of the 2011 Great East Japan Earthquake	Great East Japan Earthquake	Earthquake	0.7	Nondisplaced and Displaced	Substance Abuse	Odds Ratio	Self-Reported
Takahashi, 2016	Association between relocation and changes in cardiometabolic risk factors: A longitudinal study in tsunami survivors of the 2011 Great East Japan Earthquake	Great East Japan Earthquake	Earthquake	0.7	Nondisplaced and Displaced	Diabetes	Odds Ratio	Self-Reported
Takahashi, 2016	Association between relocation and changes in cardiometabolic risk factors: A longitudinal study in tsunami survivors of the 2011 Great East Japan Earthquake	Great East Japan Earthquake	Earthquake	0.7	Nondisplaced and Displaced	General Health Effects	Odds Ratio	Self-Reported
Takahashi, 2017	Effect of evacuation on liver function after the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	2.0	Nondisplaced and Displaced	Substance Abuse	Odds Ratio	Physician
Takahashi, 2018	Effects of lifestyle on hepatobiliary enzyme abnormalities following the Fukushima Daiichi nuclear power plant accident The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	0.5	Displaced	General Health Effects	Proportions	Physician

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Takahashi, 2018	Effects of lifestyle on hepatobiliary enzyme abnormalities following the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	0.5	Displaced	Heart Disease	Proportions	Physician
Takahashi, 2018	Effects of lifestyle on hepatobiliary enzyme abnormalities following the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	0.5	Displaced	Diabetes	Proportions	Physician
Takahashi, 2018	Effects of lifestyle on hepatobiliary enzyme abnormalities following the Fukushima Daiichi Nuclear Power Plant accident: The Fukushima Health Management Survey	Fukushima	Nuclear Power Plant	0.5	Displaced	Weight Problems	Proportions	Physician
Tally, 2013	The Impact of the San Diego wildfires on a general mental health population residing in evacuation areas	2007 California Wildfires	Fire	0.0	Nondisplaced and Displaced	Psychological Distress	Odds Ratio	Physician
Tanaka, 2016	Predictors of hypertension in survivors of the Great East Japan Earthquake, 2011: A cross-sectional study	Great East Japan Earthquake	Earthquake	0.1	Displaced	Heart Disease	Proportions	Physician
Taormina, 2008	The Chornobyl accident and cognitive functioning: a follow-up study of infant evacuees at age 19 years	Chernobyl	Nuclear Power Plant	19.0	Displaced	Other	Odds Ratio	Self-Reported

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Thienkrua, 2006	Symptoms of posttraumatic stress disorder and depression among children in tsunami-affected areas in southern Thailand	2004 Indian Ocean Earthquake and Tsunami	Earthquake and Tsunami	0.2	Nondisplaced and Displaced	Depression	Odds Ratio	Test
Thienkrua, 2006	Symptoms of posttraumatic stress disorder and depression among children in tsunami-affected areas in southern Thailand	2004 Indian Ocean Earthquake and Tsunami	Earthquake and Tsunami	0.2	Nondisplaced and Displaced	PTSD	Odds Ratio	Test
Thomas, 2012	The Impact of forced transitions on the most functionally impaired nursing home residents	Gustav	Hurricane	0.1	Nondisplaced and Displaced	Diabetes	Odds Ratio	Physician
Thomas, 2012	The Impact of forced transitions on the most functionally impaired nursing home residents	Gustav	Hurricane	0.1	Nondisplaced and Displaced	Healthcare Accessibility	Odds Ratio	Physician
Thomas, 2012	The Impact of forced transitions on the most functionally impaired nursing home residents	Gustav	Hurricane	0.1	Nondisplaced and Displaced	Mortality	Odds Ratio	Physician
Thomas, 2012	The Impact of forced transitions on the most functionally impaired nursing home residents	Gustav	Hurricane	0.1	Nondisplaced and Displaced	Heart Disease	Odds Ratio	Physician
Thompson, 2015	Stress and cortisol in disaster evacuees: An exploratory study on associations with social protective factors	2007 California Wildfires	Fire	0.0	Displaced	Anxiety	Proportions	Test
Thompson, 2015	Stress and cortisol in disaster evacuees: An exploratory study on associations with social protective factors	2007 California Wildfires	Fire	0.0	Displaced	PTSD	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Thompson, 2015	Stress and cortisol in disaster evacuees: An exploratory study on associations with social protective factors	2007 California Wildfires	Fire	0.0	Displaced	Depression	Proportions	Test
Tomio, 2010	Interruption of medication among outpatients with chronic conditions after a flood	Southwest Japan 2006 Flash Flood	Flood	0.4	Displaced	Heart Disease	Odds Ratio	Physician
Tomio, 2010	Interruption of medication among outpatients with chronic conditions after a flood	Southwest Japan 2006 Flash Flood	Flood	0.4	Nondisplaced and Displaced	Healthcare Accessibility	Odds Ratio	Physician
Tomio, 2010	Interruption of medication among outpatients with chronic conditions after a flood	Southwest Japan 2006 Flash Flood	Flood	0.4	Nondisplaced and Displaced	Diabetes	Odds Ratio	Physician
Tomio, 2010	Interruption of medication among outpatients with chronic conditions after a flood	Southwest Japan 2006 Flash Flood	Flood	0.4	Nondisplaced and Displaced	General Health Effects	Odds Ratio	Physician
Tomio, 2010	Interruption of medication among outpatients with chronic conditions after a flood	Southwest Japan 2006 Flash Flood	Flood	0.4	Nondisplaced and Displaced	Respiratory	Odds Ratio	Physician
Tomio, 2010	Interruption of medication among outpatients with chronic conditions after a flood	Southwest Japan 2006 Flash Flood	Flood	0.4	Nondisplaced and Displaced	Psychological Distress	Odds Ratio	Physician
Tsujiuchi, 2016	High prevalence of post-traumatic stress symptoms in relation to social factors in affected population one year after the Fukushima nuclear disaster	Fukushima	Nuclear Power Plant	1.0	Displaced	PTSD	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Tucker, 2017	Possible link of interleukin-6 and interleukin-2 with psychiatric diagnosis, ethnicity, disaster or BMI	Katrina	Hurricane	1.6	Displaced	Psychological Distress	Proportions	Physician
Tucker, 2017	Possible link of interleukin-6 and interleukin-2 with psychiatric diagnosis, ethnicity, disaster or BMI	Katrina	Hurricane	1.6	Displaced	PTSD	Proportions	Physician
Tucker, 2017	Possible link of interleukin-6 and interleukin-2 with psychiatric diagnosis, ethnicity, disaster or BMI	Katrina	Hurricane	1.6	Displaced	Depression	Proportions	Physician
Tucker, 2017	Possible link of interleukin-6 and interleukin-2 with psychiatric diagnosis, ethnicity, disaster or BMI	Katrina	Hurricane	1.6	Displaced	Substance Abuse	Proportions	Physician
van Griensven, 2006	Mental health problems among adults in tsunami-affected areas in southern Thailand	2004 Indian Ocean Earthquake and Tsunami	Earthquake and Tsunami	0.2	Displaced	Anxiety	Proportions	Test
van Griensven, 2006	Mental health problems among adults in tsunami-affected areas in southern Thailand	2004 Indian Ocean Earthquake and Tsunami	Earthquake and Tsunami	0.2	Displaced	Depression	Proportions	Test
van Griensven, 2006	Mental health problems among adults in tsunami-affected areas in southern Thailand	2004 Indian Ocean Earthquake and Tsunami	Earthquake and Tsunami	0.2	Nondisplaced and Displaced	PTSD	Odds Ratio	Test
Wang, 2012	Prevalence of PTSD and depression among junior middle school students in a rural town far from the epicenter of the Wenchuan earthquake in China	Wenchuan Earthquake	Earthquake	0.8	Displaced	PTSD	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Wang, 2012	Prevalence of PTSD and depression among junior middle school students in a rural town far from the epicenter of the Wenchuan earthquake in China	Wenchuan Earthquake	Earthquake	0.8	Displaced	Depression	Proportions	Test
Waugh, 2007	The long-term impact of war experiences and evacuation on people who were children during World War Two	WW2	War	60.0	Nondisplaced and Displaced	Other	Odds Ratio	Self-Reported
Yabe, 2014	Psychological distress after the Great East Japan Earthquake and Fukushima Daiichi Nuclear Power Plant accident: Results of a mental health and lifestyle survey through the Fukushima Health Management Survey in FY2011 and FY2012	Fukushima	Nuclear Power Plant	1.0	Displaced	PTSD	Proportions	Test
Yabe, 2014	Psychological distress after the Great East Japan Earthquake and Fukushima Daiichi Nuclear Power Plant accident: Results of a mental health and lifestyle survey through the Fukushima Health Management Survey in FY2011 and FY2012	Fukushima	Nuclear Power Plant	1.0	Displaced	Psychological Distress	Proportions	Test
Yoshida, 2016	Psychological distress of residents in Kawauchi village	Fukushima	Nuclear Power Plant	1.5	Displaced	PTSD	Proportions	Test
Yoshida, 2016	Psychological distress of residents in Kawauchi village	Fukushima	Nuclear Power Plant	1.5	Displaced	Psychological Distress	Proportions	Test

Table B-1 Data Used in Meta-analysis (cont.)

Author, Year	Title	Event	Type	Time between Event and Study (Years)	Groups Studied	Effect	Data Type	Data Source
Yzermans, 2005	Health problems of victims before and after disaster: A longitudinal study in general practice	Netherlands Fireworks Disaster	Explosion	2.5	Displaced	General Health Effects	Odds Ratio	Test

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10. SUPPLEMENTARY NOTES

A. Sharp

11. ABSTRACT (200 words or less)

Evacuations are important tools to protect public health and safety and a principle protective action in response to a radiological emergency. Although evacuations can be important to prevent exposure following emergency events, they are not without their own risks. Previous research has identified these risks, but the aggregate of the risk has not been quantified. This study includes a meta-analysis of 14 health effects experienced by evacuees and relocated populations. Effects studied included anxiety, heart disease, mortality, and others. Following a literature review of over 1,200 papers, the authors included 82 papers in the meta-analysis. The likelihood of an effect in a population was estimated using odds ratios and the prevalence of health effects in displaced and nondisplaced populations across various hazards. A meta-regression was performed to identify which event factors contributed to unusually high or low prevalence of health effects among displaced or nondisplaced populations. The meta-analysis showed an association between displacement and an increase in all the negative health effects studied. Additionally, a higher prevalence among displaced populations was statistically significant for nine health effects. These findings suggest that evacuation or relocation have associated long-term risks as a result of the prolonged displacement.

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