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Tsunami knowledge, information sources, and evacuation intentions among tourists in Bali, Indonesia

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Abstract

Bali is highly susceptible to earthquake-generated tsunamis. The island attracts millions of visitors each year, yet little is known about tourists' tsunami information sources prior to and while visiting Indonesia, perceived causes of tsunamis, perceptions of tsunami evacuation windows, and evacuation intentions. We created inundation maps for high-tourist areas of Bali, conducted multiple-choice surveys of tourists in English, Japanese, and Chinese, conducted informal interviews of hotel and government officials, and assessed topography of high tourist areas for safe evacuation sites. 75.3% of tourists reported that they had not learned about tsunamis while traveling in Indonesia. 24.3% had not learned about tsunamis prior to traveling to Indonesia. 84.2% recognized that tsunami events could be triggered by earthquakes; however many incorrectly attributed tsunami causes to events such as storms (24.7%), climate change (22.0%), and lunar gravitational pull (12.8%). Although our numerical model showed a 15–20 min evacuation window after earth shaking, 42.1% of tourists believed they would have more than 30 min to evacuate. Most participants reported intentions to run uphill (85.5%), inland (42.8%) or up the stairs of a tall building (34.2%). There is increased opportunity for government and tourism providers to disseminate knowledge of tsunami natural warning signs and specific evacuation instructions at airports, hotels, beaches, and tourism websites. Due to Bali's topography, these educational efforts may not be effective unless additional Temporary Evacuation Shelters are built in high tourist areas lacking hills. Additional disaster mitigation recommendations are provided.

Keywords Disaster mitigation · Coastal tourism · Natural hazards · Tsunami · Emergency preparedness

Introduction and literature review

Tourism and natural hazards

Coastal areas and island destinations with beautiful beaches, coral reefs, surfing opportunities, and exotic scenery are often at risk of earthquakes, tsunamis, hurricanes, and volcanic eruptions (Murphy and Bayley 1989). International tourists often flock to such areas due to the attraction of their geographic features. As these coastal areas have been developed for tourism, the potential of tsunami disaster has increased due to the high density of visitors and depletion of natural resources. Niman (2010) reported that during the 2004 tsunami, damage was greatest in areas with depleted coral reefs and destroyed mangrove forests. Mangrove forests in Indonesia form natural tsunami barriers yet many forests have been destroyed for resort and beach development, shrimp farms, and wood export. Coral reefs have likewise been depleted due to tourism. These factors put residents and tourists visiting beach areas at greater risk of tsunami disaster.

Unfamiliarity with the local language, terrain, and infrastructure pose unique risks to tourists' ability to receive warnings and evacuate. Expectations of warning via siren and lack of knowledge of tsunami natural warning signs (e.g. earthquakes, receding ocean) may cause deadly evacuation delays (Kelman et al. 2008). There is some evidence that tourists, especially international tourists, may be less aware of tsunami

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risk, warning signs, and tsunami arrival times when compared to residents (Fraser et al. 2013). Drabek (2000) found high numbers of tourists who experience natural disasters while traveling reported sleeping in shelters, roadside restaurants, and cars; local residents were likely to seek shelter with friends and relatives. These tourists believed they had less warning than local residents prior to the disaster, with 40% reporting that the warnings did not have specific information and that they wanted confirmation from tourism staff, other tourists, or relatives.

Preparedness initiatives are essential to reducing mortality, injury, and psychological distress. While there is a wealth of research on community disaster preparedness, few studies have focused on tourist tsunami vulnerability. Existing studies related to natural hazards and tourism focus primarily on disaster response and recovery *after* a major disaster occurs, with few studies focusing on preparation and mitigation (Ritchie et al. 2011). Likewise, although literature on disaster preparedness in the hotel sector has increased, the priority has been on post-disaster resilience with few studies on hotel preparedness (Virapart 2011). Esteban et al. (2013) distinguishes two important levels of preparedness: institutional and citizen levels. While this is typically applied to government and local populations, we apply the framework to tourism providers (institutional level) and tourists (citizen level).

The natural geologic features that draw tourists to coastal areas often results in the depletion of natural tsunami barriers in these areas. This may increase risk of disaster for tourists and locals when a tsunami occurs. Tourist unfamiliarity with local terrain, language, and infrastructure places tourists in a particularly vulnerable position when hazards occur, especially if there is insufficient planning at the institutional level or knowledge of disaster risk and evacuation protocol at the individual level. There have been few studies on disaster preparedness relating to tourism in coastal areas.

Institutional level - tourism providers

Becken et al. (2014) collected qualitative data on tourism disaster vulnerability in small island destinations and contend that, "probably, the most critical vulnerability driver is the lack of private sector investment in disaster risk reduction. This is interrelated with deficient planning processes, ongoing demand for coastal products, lack of political will, and poor environmental conditions" (p. 955). Faulkner (2001) proposed a model for institutional tourism disaster management strategies. In the pre-event strategies, the model includes a Disaster Management Team, identifying public/private sector organizations, establishing a communication system, developing and communicating a Disaster Management Strategy, education, and agreement on and commitment to activation protocols. On the risk assessment side of pre-event planning, this includes assessing potential disasters and the probability that they will occur, developing scenarios on disaster impact, and disaster contingency plans. Few studies have explored institutional commitments to these efforts.

Tourism managers' perceptions of natural hazard risk are important to creating disaster mitigation and preparedness strategies (Meheux and Parker 2006). Drabek (1995a, b) found that tourism business executives too often begin planning for disaster only *after* the disaster has taken place with decisions being made ad hoc as the situation worsened. After the 2004 tsunami, Thailand instituted an Early Warning System and community awareness and resilience programs. However, tsunami preparedness measures for the tourism industry was not undertaken (Virapart 2011). Several studies have found poor levels of disaster preparedness in the tourism industry including staff training, disaster protocols, tourism specific plans, and little coordination between the tourism industry and emergency services (Orchiston 2013; Johnston et al. 2007; Faulkner and Vikulov 2001). In a study on tsunami preparedness among tourism providers in Washington, only 22% of staff reported exposure to training on hazard events, and only one business had tsunami signs in rooms (Johnston et al. 2007). Small businesses have been found to have fewer resilience tools (Orchiston 2013) and worse preparedness measures compared to larger organizations that have been around longer (Ritchie et al. 2011), while larger organizations had orientations or training programs in place that could more easily integrate disaster preparedness into the curriculum (Johnston et al. 2007).

After a forest fire in British Columbia, which included the destruction of several major tourist attractions, Hystad and Keller (2008) identified barriers to disaster preparedness planning faced by tourism businesses. Lack of funding, lack of knowledge of disaster management plans, business size, and perceived lack of cohesiveness in the tourism industry were among barriers reported by tourism providers. Drabek (1995a, b) concluded that the best way for tourism providers to prepare for natural disasters is through "planning appropriate actions, resisting denial, having a single person in charge, improving employee and customer communication, anticipating the needs of special populations, and recognizing family priorities, as well as structuring media relations." Drabek (2000) further recommended increased staff training and disaster drills by tourist accommodation providers. Seville et al. (2006) cites interdependence between organizations and the importance of working together, asserting that no organization can work unilaterally to effectively respond to major crises. Tourism providers have the potential be important institutional allies to government in disaster planning and mitigation, tourist education, and instigating evacuation.

Tourists' expectations of tourism providers (e.g. hotel managers, resorts) responsibility to protect them from natural disasters appears to differ greatly from providers' perceptions of their own responsibility. In Thailand, Rittichainuwat (2013)

found that tourists at guesthouses placed the highest importance on safety measures while guests at upscale hotels had the lowest perceived importance of safety measures, and that most tourism suppliers do not want to remind tourists of tsunami risk. Drabek (2000) found that tourists desired better evacuation planning, transmission of information about hazard risk, improved warning policies, and road evacuation directions from providers. Tourists were more likely to believe providers had little to no commitment to disaster evacuation planning and more likely to believe that local government should require accommodations to have disaster evacuation plans. However, providers were more likely to believe their disaster preparations were adequate and less likely to believe that the local government should require tourist accommodations to have disaster evacuation plans. Additionally, while more than one-third of managers reported that it was their policy to wait for an order from local officials before instigating an evacuation in the event of an emergency, only 17% of tourists believed managers would wait for an official order (Drabek 2000). Qualitative interviews with tsunami survivors in Thailand supported a disconnect between tourist expectations and resort preparedness, with interviewees asserting that with communication lines down after the tsunami, resort staff often did not know what to do, that there was a lack of emergency plans at the resorts, and that there were no supplies (e.g. stretchers, first aid kits) available at the resorts after the tsunami occurred (Kelman et al. 2008). The expectations gap could put tourists who rely on accommodation providers for safety at unnecessary risk, especially if they wait to receive evacuation instructions or clarifications from hotel or resort staff.

There are many obstacles to tsunami preparedness at the institutional level including lack of prioritization, funding, knowledge, staff training, resources, and coordination between entities. Several studies have found that tourist providers consider their planning adequate while tourists expect more from the providers. Limited studies from previous tsunamis have shown that resorts lacked knowledge and resources to adequately care for tourists during a tsunami event.

Citizen level - tourist perceptions, knowledge, and evacuation intentions

Understanding warnings, how to respond to the warning, and being able to successfully evacuate are critical to survival in the event of a tsunami. There is little research on tourist perceptions of hazard risk, knowledge of the nature of the hazard, understanding of the local warning systems and communication procedures, and what tourists intend to do in the event of the hazard. For tsunamis, other critical knowledge for tourists include awareness of natural tsunami warnings signs, perceptions of how to successfully evacuate, and familiarity with the terrain and infrastructure.

Low perceived risk leads to lower preparedness levels (Rittichainuwat et al. 2018) and is likely to decrease evacuation response speed (Dash and Gladwin 2007). Response speed is important since there is only a small evacuation window (as little as 10–20 min in some areas of Indonesia) after an earthquake occurs before a catastrophic tsunami may hit (Post et al. 2009). Perceptions of risk and the importance of tsunami preparedness and mitigation efforts have been found to correlate with whether a tsunami event had previously occurred in the area and how long ago the disaster occurred. International tourists who survived the 2004 megatsunami reported that they had a lack of tsunami risk awareness prior to the tsunami event (Kelman et al. 2008). Tourists in countries that had been hit by the 2004 tsunami 10 years earlier overall knew that the location they visited was prone to tsunamis but had a low perceived risk of another tsunami occurring during their visit. These perceptions were related to low frequency of tsunami occurrence in the area (Rittichainuwat et al. 2018). Tourists interviewed 6 years after the 2004 tsunami but before the 2011 Japan tsunami had lower perceived importance of tsunami safety measures than those surveyed after the 2011 Japan tsunami indicating that a recent disaster increases perceived importance (Rittichainuwat 2013).

Tourist knowledge of the nature of disasters and how to respond to them are critically important to saving lives. Although studies on tourist knowledge of tsunami natural warning signs are scarce, there is some evidence that knowledge of natural tsunami warnings signs is low. A study in New Zealand found that 95% of regional and national visitors believed a tsunami was possible in Napier after ground shaking compared to only 57% of international visitors (Fraser et al. 2013). Only 15% of visitors reported tidal change or sea waves as potential sources of tsunami warning; 67% cited that a siren is a tsunami warning sign (Fraser et al. 2013). International tourists who survived the 2004 tsunami reported that they underestimated both the speed in which a tsunami occurs and the level of destruction wrought by tsunamis. These respondents reported feeling an earthquake but failing to evacuate, noting they wished they would have known a receding ocean was a tsunami warning sign (Kelman et al. 2008).

There are very few studies on tourist evacuation intentions. One study performed by Fraser et al. (2013) in New Zealand offers evidence that international tourists may not be as aware of the need to evacuate after a sustained earthquake compared to other types of visitors (100% of regional visitors, 92% of local visitors, 67% of international visitors). Additionally, 93% of national visitors reported high ground or uphill as being safe locations during a tsunami compared to only 53% of international visitors. Locals and national visitors had more realistic views of evacuation windows while international

tourists overestimated the amount of time they would have to evacuate prior to a tsunami event.

Tourists' level of perceived risk, knowledge of warning signs, and how to successfully evacuate are essential to saving lives during a tsunami event. Limited research has suggested that international tourists may have low perceived risk of a tsunami occurring during their visit, lack understanding of tsunami natural warning signs, underestimate tsunami speed and destructiveness, and underestimate the duration of tsunami evacuation windows. Our study adds to this literature by assessing tourist knowledge and evacuation intentions in Bali Indonesia.

Early warning systems

Early Warning Systems (EWS) have been instituted for natural disasters across the world. Strunz et al. (2011) notes the capabilities of individuals to respond to these warnings include: "warning dissemination (do people receive and understand the warning?), anticipated response (do people respond to warnings and evacuate?) and evacuation (are people able to reach safe areas on time?)" (p. 72). For example, the Indonesian Tsunami Early Warning Systems (InaTEWS) instituted after the 2004 tsunami event was designed to warn anyone in earshot of an impending tsunami.

Warning dissemination has been historically impeded by technical issues in communication infrastructure, which causes some rural coastal populations to fail to receive the warning resulting in loss of life during the 2010 Mentawai tsunami (Geofisika 2010), early termination of the warnings even when additional tsunami waves continued as was the case in the Mentawai 2010 and Japan 2011 tsunamis (Suppasri et al. 2015), and lack of governmental guidance and trust in the system (Spahn et al. 2010).

Even if the warning is received, tourists must have knowledge of how to respond and evacuate. The ability to reach a safe area in time includes factors such as knowledge and presence of safe places to evacuate such as Temporary Evacuation Shelters (*Tempat Evakuasi Smentara–TES*) or hilly areas as well as geographic and infrastructure factors such as steepness, population density, transportation networks, and evacuation bottlenecks (Løvholt et al. 2014; Post et al. 2009). Demographic factors such as age, pregnancy, physical fitness, or physical disability also influence response capability (Sullivan and Häkkinen 2006; Løvholt et al. 2014).

There is evidence that tourists rely too heavily on sirens and not enough on natural warning signs for tsunami evacuation despite the lapses, delays, and failures of EWS that reduce evacuation speed (Fraser et al. 2013; Kelman et al. 2008). At the institutional level, accommodation providers have the potential to create systems for disaster mitigation such as communication trees and cross checks to disseminate warnings and instructions (Faulkner and Vikulov 2001), evacuation plans, and other mitigation efforts. The technical and human failures of EWS in past disaster events suggest that individual knowledge of natural tsunami warning signs (e.g. earthquakes, receding oceans) and how to respond to these warnings through immediate self-evacuation are critically important (Hall et al. 2017).

Technical failures of Early Warning Systems demonstrate the need for recognition of natural tsunami warning signs and self-evacuation. Historically, there has been an overreliance on tsunami sirens as a cue for evacuation. Accommodation providers have an opportunity to educate tourists about tsunami risk, natural warning signs, and how to respond when confronted with these warnings to increase tourists' efficacy in the event of a tsunami. There is also an opportunity for tourism providers to create and implement evacuation plans, communication trees, and other mitigation strategies.

Tsunamis in Indonesia

Indonesia is the most seismically active country on Earth and one of the most densely populated. The archipelago is situated on the active Sunda plate boundary, which is notorious for mega-disasters (Harris and Prasetyadi 2002). Most natural disasters in Indonesia are caused by tsunamis, which over the past 430 years happen on average once every 4 years (Hamzah et al. 2000). Tsunami disaster mitigation research in Indonesia began in earnest in North Sumatra and elsewhere *after* the 2004 event that killed over 200,000 people (Muck 2008; Lay et al. 2005). Since then, tsunamis have occurred in Indonesia in Nias in 2005, Java in 2006, Mentawai in 2010, and Sulawesi in 2018, killing thousands more.

Some of the largest earthquakes, tsunamis, and volcanic eruptions known happened in Indonesia during the nineteenth century (Harris and Prasetyadi 2002). Since then, population and urbanization have increased exponentially in areas formerly destroyed by these events. Now that there is much more to lose, even relatively small events claim more lives and resources than before. Multiple types of measurements indicate that what happened in the nineteenth century is starting to recur (Harris and Major 2016). Historical records indicate that numerous plate boundary segments have not ruptured for more than 430 years. During this time, enough pressure has accumulated to produce mega-earthquakes capable of triggering large tsunamis in several parts of the Sunda Arc and in eastern Indonesia (Liu and Harris 2013) including the most densely populated coastal areas of Bali.

The problem for Bali and many other densely populated tourist areas in Indonesia is the proximity to plate boundaries that are generating tsunamis. Tsunamis travel at high speeds in the open ocean, which limits the evacuation time for those communities that actually feel the earthquake to as little as 20 min. EWS are ineffective in these situations, which is the most common scenario in Indonesia.

Indonesia is one of the most at-risk areas for tsunamis on earth. The popularity of Bali and other Indonesian islands as tourist destinations coupled with recent tsunamis in Indonesia call for increased preparedness and mitigation measures. Mitigation strategies calling for self-evacuation after an earthquake, regardless of the strength of shaking, is essential to saving lives.

Tourism in Bali

In 2017, Bali was honored by TripAdvisor as the winner of its annual Travelers' Choice awards for destinations across the world. Next in line were London, Paris, Rome and New York (Paris 2017). This list of top destinations was determined "by an algorithm that judges the quality and quantity of users' reviews and ratings for hotels, restaurants and attractions" and also booking interests of travelers (Nurhayati 2017). For the year 2016, *Travel and Leisure* noted that the most searched travel question on Google was: "Where is Bali?" (Plautz 2016). Perhaps, that inquiry rises from travelers who read about Bali on lists of top tourist destinations in the world and yet do not know where the island is located. If they do not know where it is located, then it is likely they are unaware of its seismic and tsunami hazards.

According to the Bali Government Tourism Office, nearly 5 million (4,927,937) tourists entered Bali from more than 110 countries during 2016. During the low season, more than 350,000 tourists entered Bali each month while nearly half a million entered during high tourism months (Fig. 1). The percentage of tourists entering Bali from various world regions included Asia Pacific (61.6%), Europe (21.9%), the Americas (5.5%), Asia (8.5%), Africa (0.6%), Middle East (1.0%), and other (0.9%). The highest percentage of tourists were Australian (23.2%), Chinese (20.1%), Japanese (4.8%), British (4.5%), Indian (3.8%), Malaysian (3.7%), American (3.5%), French (3.4%), German (3.1%), and South Korean (3.1%) (Bali Government Tourism Office 2018a, b).

Tourist attractions in Bali include diverse destinations and activities such as beaches, scuba diving, surfing, white water rafting, mountain biking, temples, rice terraces, cultural shows, monkey forests, markets, and luxurious spas. However, tourism has developed unevenly across the island with most of Bali's transportation infrastructure, including the Ngurah Rai International Airport, and most of its hotels clustered along the southern and more tsunami-prone half of the island. In 2015, the Badung regency that includes the beautiful beach areas to the south and west of Denpasar, listed 49,790 tourist rooms out of a total of 78,165 rooms on the entire island. These rooms were located in 154 starred hotels (*hotel bintang*), 472 non-starred hotels (*hotel melati*) and 441 guest house/homestay (*pondok wisata*) (Bali Government Tourism Office 2018a, b). Many of these accommodations for tourists are located in low areas that would be inundated in the event of a tsunami.

At the heart of that inundation zone, the former fishing village of Kuta with its sandy beaches, surfing, cultural events, restaurants, bars, and nightlife is a favorite tourist destination with many beachfront hotels. This beach-oriented area is also one of the most tsunami-vulnerable areas of Bali due to the lack of availability of nearby hills for evacuation, lack of evacuation shelters and tall buildings, and difficulty of inland evacuation due to already congested roads leading away from the narrow peninsula. A siren associated with a Tsunami Early Warning System is tested each month, but the soonest a warning has been delivered by this system is more than 30 min after a tsunami-generating event.

The tsunami hazard map we produced (Fig. 2) identifies areas for evacuation immediately after sustained earthquake

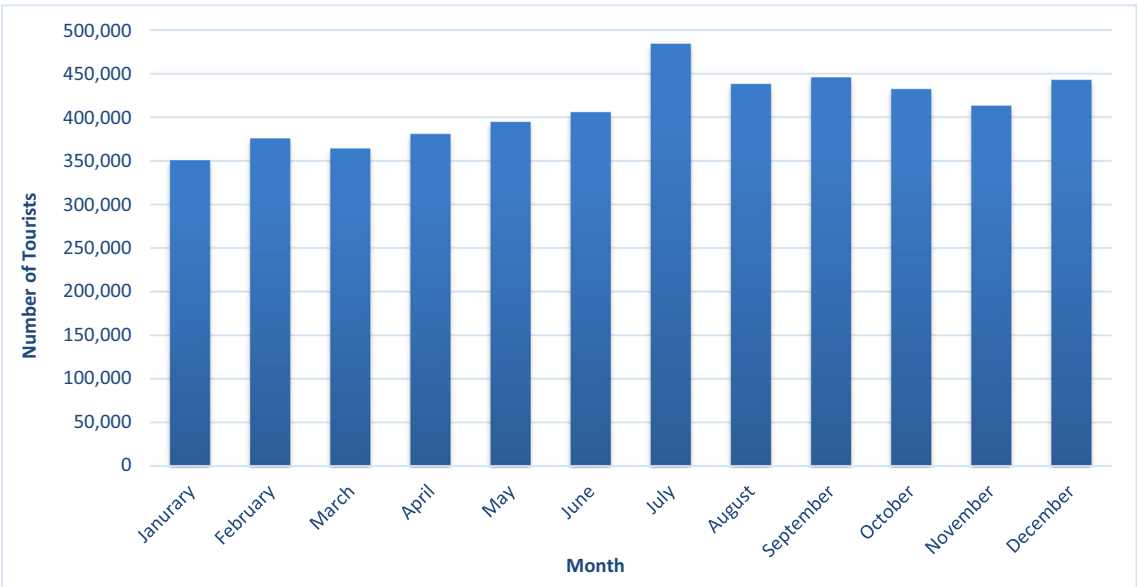


Fig. 1 Number of tourists entering Bali each month in 2016 according to the Bali Government Tourism Office

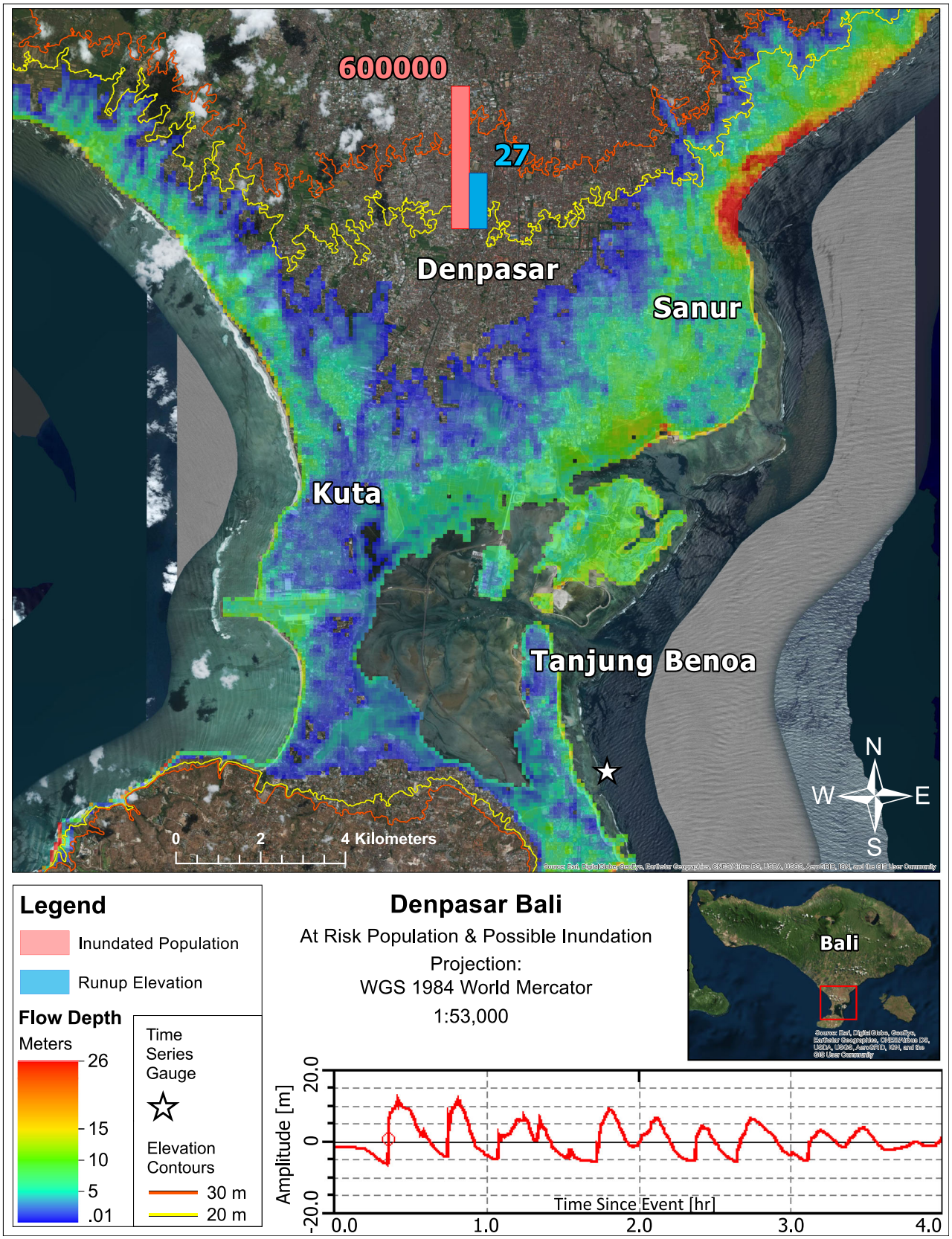


Fig. 2 Tsunami inundation map of Denpasar, Indonesia using a megathrust earthquake along the Java Trench (inset map on right). Uncertainties in the data arise from different methods of extrapolating population. These data are suitable for 1st order estimate of the extent of likely tsunami flooding

shaking, even if it is not intense shaking. Community Model Interface for Tsunami or ComMIT (Titov et al. 2011) interface was used to models earthquake, transoceanic propagation, and inundation of dry land. Population within inundation zones in Bali for each city or region were calculated using two data sources: World Pop (2014) projected 2020 census distribution (Gaughan et al. 2013) and the 2015 European Commission, Joint Research Centre (JRC) census distribution. The 3.3 km long, rectangular feature in green just south of Kuta is the international airport. Bar graphs show estimates of minimum population in the tsunami inundation zone (pink) and maximum run-up elevation (blue). Flow depth of the inundating wave/flood is projected onshore using a stretched color scale. Maximum run-up meters above sea level and an estimate of population at risk is shown in the bar graph. The earthquake used to generate the tsunami was modeled to represent a worst-case scenario (28 m of slip).

The tourist city of Kuta has maximum wave amplitude of 10–15 m and a flow depth of about 10 m. A 20 and 30 m elevation contour is included for reference of elevations inhabitants may have to reach to escape from the tsunami. The time series displays the expected time of wave arrivals and wave amplitude (meters above sea level) located at the simulated tidal gauge (white star). Multiple waves are shown, the first arrives at around 20 min from the initiation of the earthquake. The second wave is even larger and arrives 40 min after the earthquake shaking.

The inundation map we created raises significant concerns about tsunami disaster mitigation in southern Bali. Siren warnings would be insufficient to safely evacuate most tourists in Bali. Our numerical models show the first tsunami wave arriving within 20 min of earthquake shaking. During an earthquake like the one expected offshore near Bali, most residents in the region will not be able to do anything for at least 5 min because of the heavy shaking. After the shaking stops, there will only be about 15 min to respond. If residents wait another 5–10 min for a warning, which only some will receive, little to no time will remain to evacuate.

According to our inundation map, most residents without a vertical evacuation option will have to travel by foot a minimum of 3 km through crowded streets to escape the tsunami. The limited vertical evacuation sites available will likely only be able to accommodate those in the immediate area around the building. Any effective strategy for tsunami disaster mitigation in southern Bali must accept the reality that immediate evacuation after sustained earthquake shaking is the only viable evacuation plan. This makes tourist knowledge of natural tsunami warning signs (e.g. sustained earthquake shaking for more than 20 seconds) vitally important to prevent loss of life in the event of a tsunami (Hall et al. 2017).

We chose Bali to conduct our research due to its high vulnerability to tsunami, the severity of likely tsunami events in terms of death toll, and the large number of tourists. Other factors that place Bali at increased risk include the necessity for inland evacuation in high tourist areas that lack hills and tall buildings, congestion resulting from evacuation on narrow roads (especially on the southern peninsula), and the limited evacuation window. It is vital that tourists know natural warning signs, do not wait for a siren to alert them, and know where to go in the event of an earthquake that may generate a tsunami.

The current study

Multidisciplinary research beyond hard sciences such as geology is critical to assessing and implementing appropriate disaster mitigation strategies (Sorooshian 2005). This includes the field of public health (Shoaf and Rottman 2000) in assessing risk perceptions and implementing appropriate interventions. We performed a multidisciplinary study of tourist tsunami vulnerability that can serve as a model of risk assessment.

Our study examines disaster mitigation at the institutional and citizen levels as related to tourists in Bali and provides an interdisciplinary approach to assessing disaster risk prior to intervention implementation. Our study provides a survey assessing tourists' tsunami risk perceptions, perceptions of tsunami causes, tsunami knowledge sources, and evacuation intentions. These efforts were supplemented by informal assessments of availability of vertical buildings, observations of tsunami evacuation signs and terrain, and interviews with government leaders, hotel staff and managers, and citizens.

Methods

We developed pen/paper surveys that included questions about where tourists learned about tsunamis prior to and while visiting Indonesia, perceived cause of tsunamis, perceptions of the tsunami evacuation window, and evacuation intentions. Surveys were generated in English, Chinese, and Japanese based on 2016 statistics of Bali tourist nationalities. In 2016, the highest percentage of tourists were Australian (23.2%), Chinese (20.1%), and Japanese (4.8%), with all other nationalities representing less than 4.5% of tourists.

Participants were recruited in high-tourist areas in and around Kuta such as cultural shows and at the airport on their way home. There was no incentive given for taking the voluntary survey. Survey respondents were sorted into regions by their home countries. Responses were calculated for all survey participants and further broken down into the regions of Asia, Europe, Australia and New Zealand, and North America. There were not adequate sample sizes to represent all regions (such as South America and Africa) in separate calculations, although all respondents were included in the "all responses" calculation.

We augmented our survey research with informal interviews with local government officials, school

administrators, and hotel managers and administrators. We visited areas deemed tsunami-safe that were recommended through these interviews, including four high-end hotels in Tanjung Benua, three hotels in Kuta and Seminyak, and Bali's single TES.

Results

Participants

304 tourists from at least 40 countries and six continents participated in the survey. Survey participants came from Asia ($N = 111$, 36.5%), Europe ($N = 102$, 33.6%), Australia and New Zealand ($N = 27$, 8.9%), North America ($N = 35$, 11.5%), South America ($N = 11$, 3.6%), Africa ($N = 1$, 0.3%), and no response ($N = 17$, 5.6%). Countries most represented as a percentage of the total sample were India (10.9%), United States (8.9%), Australia (8.2%), Japan (8.2%), China (7.7%), France (4.6%), United Kingdom (4.3%), Belgium (4.3%), Germany (3.0%), the Netherlands (3.0%), and Switzerland (3.0%). Countries representing <3% of the sample each (5–9 respondents) were Canada, Malaysia, Russia, Singapore, and Spain. Countries representing <1.6% of the sample each (<5 respondents) were Brazil, Denmark, Ireland, Norway, Sweden, Argentina, Paraguay, Portugal, Vietnam, Italy, New Zealand, Philippines, Austria, Bangladesh, French Caribbean, Luxembourg, Mexico, Myanmar, Republic of Korea, Saudi Arabia, Trinidad and Tobago, Turkey, United Arab Emirates, and Zimbabwe. 22 respondents did not specify a country. Of respondents, 55.6% were female, 39.8% were male, and 4.6% were "other" or did not answer. Ages of respondents were 18–25 years (33.9%), 26–30 years (19.4%), 31–35 years (8.6%), 36–40 years (7.6%), 41–45 years (7.2%), 46–50 years (5.6%), and 51+ years (14.8%). 3.0% did not respond to the question.

Tourist tsunami knowledge sources in Indonesia

Participants were asked to select where they had learned about tsunamis while traveling in Indonesia (Table 1). Participants were able to select all answers that applied.

The majority of participants (75.3%) reported that they had *not* learned about tsunamis while traveling in Indonesia. A minority of participants reported learning about tsunamis through warning and evacuation signs in Indonesia (12.8%), TV (6.6%), and hotel (4.9%). 3.0% or fewer respondents reported hearing about tsunamis through their travel agent, local people, brochure/pamphlet/reading material, Internet, and airport. Other (write-in) responses included "wife who is traveling with me on our honeymoon," "dad," "book," and "billboard at the beach" (Fig. 3).

Table 1 Tsunami knowledge sources among tourists in Bali

Question	$N = 304$	%[a]
Please select where you have learned about tsunamis while traveling in Indonesia. Select all that apply.		
Hotel	15	4.9%
Travel Agent	9	3.0%
Warning / Evacuation Signs	39	12.8%
Local People	6	2.0%
Brochure / Pamphlet / Reading Material	9	3.0%
TV	20	6.6%
Airport	5	1.6%
Internet	7	2.3%
Other	15	4.9%
Did not learn about tsunamis while traveling in Indonesia	229	75.3%
Where did you learn about tsunamis before traveling to Indonesia? Check all that apply.		
School	120	39.5%
Friends/Family	49	16.1%
News Media	184	60.5%
Fictional Movies	65	21.4%
Internet	103	33.9%
Non-fictional Movies or TV / Documentaries	58	19.1%
Other	11	3.6%
I did not learn about tsunamis before traveling to Indonesia	74	24.3%

[a] Totals may not add up to 100% for combined responses per question due to the "select all that apply" nature of the question and because some respondents did not answer the question

Tourist tsunami knowledge sources prior to Indonesia

24.3% of respondents reported that they had *not* learned about tsunamis before traveling to Indonesia (Fig. 4). Participants reported learning about tsunamis through news media (60.5%), school (39.5%), Internet (33.9%), fictional movies (21.4%), non-fictional movies/documentaries (19.1%), friends/family (16.1%), and other (3.6%). Other (write-in) responses included "ocean ed in VA, USA," "I live in Andaman and Nicobar Islands," "Japanese tsunami," "living in Japan," "Thailand tsunami," "books," "newspaper," and "parents."

Tourist perception of tsunami causes

The majority of tourists (84.2%) correctly believed earthquakes cause tsunamis (Fig. 5). Other possible causes of tsunami were selected less frequently: landslide (28.6%), volcanic eruption (46.4%), and meteor (31.6%). Events that would not cause a tsunami varied in frequency of selection: severe storm (24.7%), global warming (22.0%), lunar gravitational pull on earth (12.8%), typhoon (21.1%), extreme temperatures

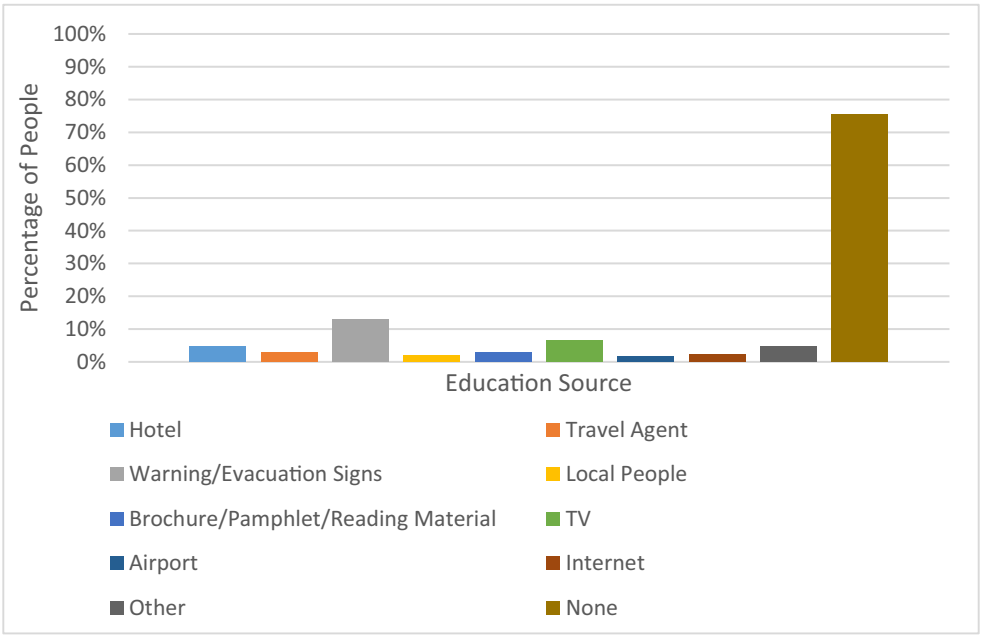


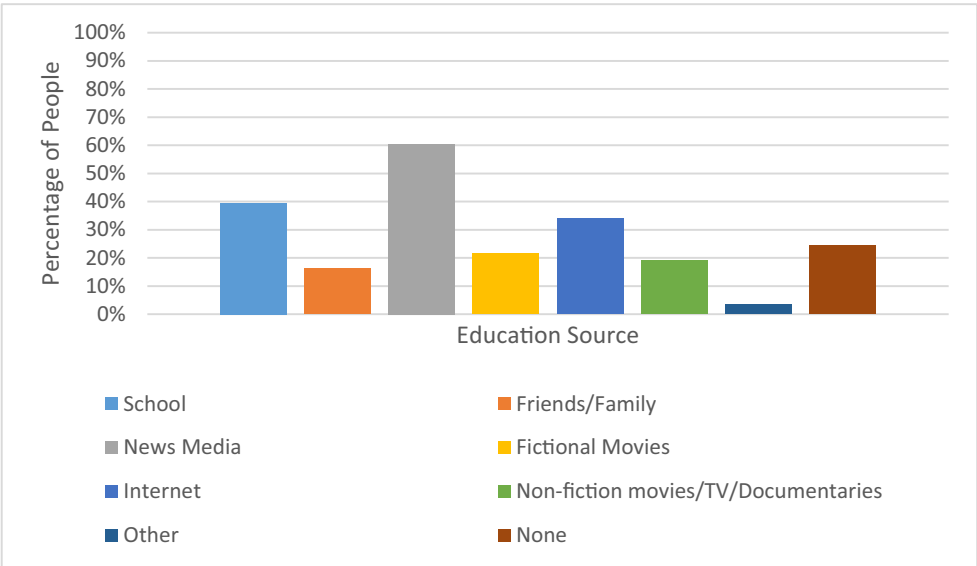
Fig. 3 Tsunami education sources while traveling in Indonesia

(8.2%), and other (4.6%). Other responses included "nuclear bomb," "tectonic plate shift/movement," "hurricane," "God's will," "SIMA buckling under continent," "earthquake in the sea," "conspiracy," and "no idea."

Regional differences were found in the identification of tsunami-generating events. 100% of Australians and New Zealanders identified earthquakes as possible causes of tsunami while North America (94.3%) and Europe (90.2%) were also high. However, only about three quarters (76.6%) of respondents from Asia correctly identified earthquakes as potential sources of tsunamis. Only 54.5% of respondents from India identified earthquakes as tsunami triggers compared to 96.0% of respondents from Japan. A higher percentage of Europeans correctly identified landslides as a tsunami cause (41.2%) compared to the other regions analyzed (22.5–25.9%). The belief that a volcanic eruption could cause a tsunami varied widely by region (e.g. Asia 36.0%; Australia and New Zealand 66.7%). North Americans (42.9%) and Europeans (41.2%) were much more likely to believe a meteor could cause a tsunami compared to Asians (20.7%) and Australians and New Zealanders (25.9%).

There were some regional differences in misconceptions of what can generate a tsunami. There were no major differences in the belief that global warming could cause tsunamis when

Fig. 4 Tsunami education prior to traveling to Indonesia



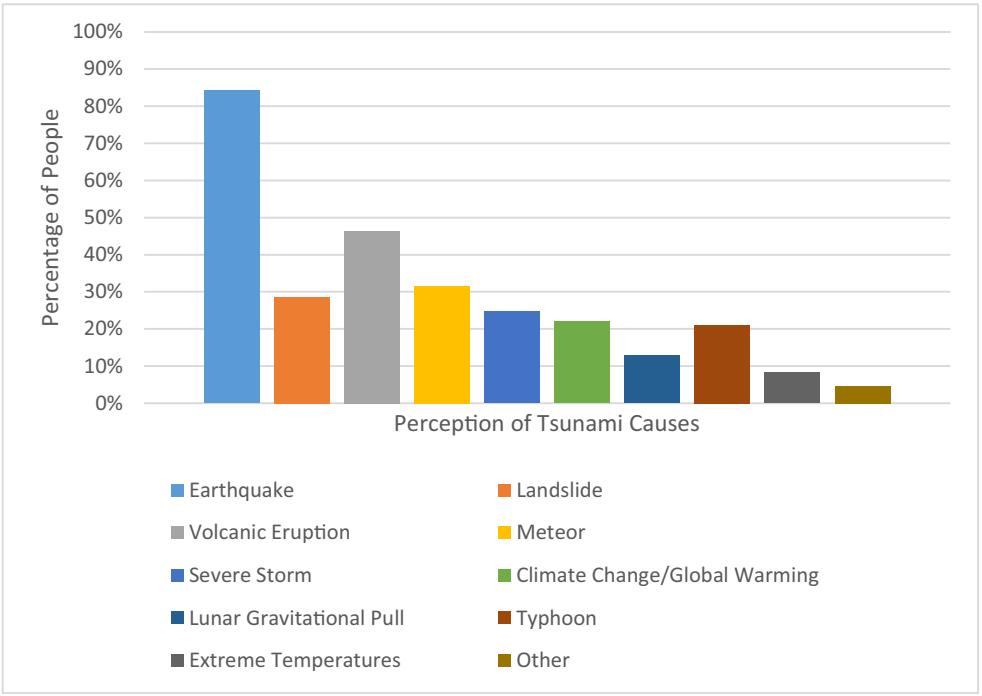


Fig. 5 Tourist perception of tsunami causes

analyzed by region (21.6–22.9%). Although 12.8% believed that lunar pull on the earth could generate a tsunami, Europeans (8.8%) were less likely to believe this than other regions (14.3–16.2%). North Americans (40.0%) were more likely to believe severe storms could cause tsunamis compared to other regions (20.7%-23.5%). Australia and New Zealanders were less likely to believe typhoons could cause tsunamis (11.1%) compared to other regions (20.7–25.7%). 8.2% of overall respondents believed extreme temperatures could cause tsunamis; however this varied widely by region (e.g. Australia/New Zealand 0%; North America 17.1%).

Tourist evacuation intentions

While more than half (56.3%) of participants believed they had <30 min to evacuate (Fig. 6), this left 42.1% of participants believing they had more than 30 min to evacuate: 30 min-1 hour (25.3%), 1–2 hours (11.2%), 2–3 hours (5.6%). 85.5% of participants said they would run up a hill or to higher ground if a tsunami was coming, 42.8% reported they would run inland, and 34.2% reported that they would run up the stairs of a tall building. Fewer reported that they would run into a building and barricade the door (3.9%) or run towards the ocean (2.0%) (Table 2).

Discussion

More than ¾ of the respondents reported that they did not learn about tsunamis while traveling in Indonesia. Only 12.8% reported tsunami warning and evacuation signs as a source of education. Fewer than 5% reported learning about tsunamis through a hotel, travel agent, reading material, or airport. There is an opportunity to educate through these channels on specifically where to go and what to do if tourists feel an earthquake, but if they wait to hear a siren there will likely not be enough time to evacuate.

Nearly three-quarters (73.4%) of respondents reported learning about tsunamis prior to traveling to Indonesia, which, potentially, but not necessarily, includes learning about tsunami causes and evacuation time. News media, schools, Internet, fictional movies, documentaries, and friends/family can potentially alert people of tsunami dangers and causes as well as help people understand the importance of uphill evacuation before a tsunami reaches the shore. However, learning about tsunami events prior to Indonesia does not necessarily translate to specific information about where to go when a tsunami happens in Bali, especially with the lack of available hills and limited number of tall buildings available in and around Kuta.

Governmental efforts since the 2004 tsunami have included tsunami evacuation signs posted around the island. Most of these signs are orange or red with a large cresting wave and a stick figure human representation running away from the wave and up an incline to safety. The signs are designed to point the way to safe areas inland or up in buildings. Since only 12.8% of our survey sample reported improved knowledge of tsunamis through this sign, it is doubtful the signs alone are sufficient to alert tourists of what to do in a tsunami event. Additionally Cox (2001) asserts that the representations of the tsunami wave as steep and breaking is likely to create misconceptions of how incoming tsunamis appear, causing individuals to fail to evacuate. Tsunamis approaching shore are often perceived as large

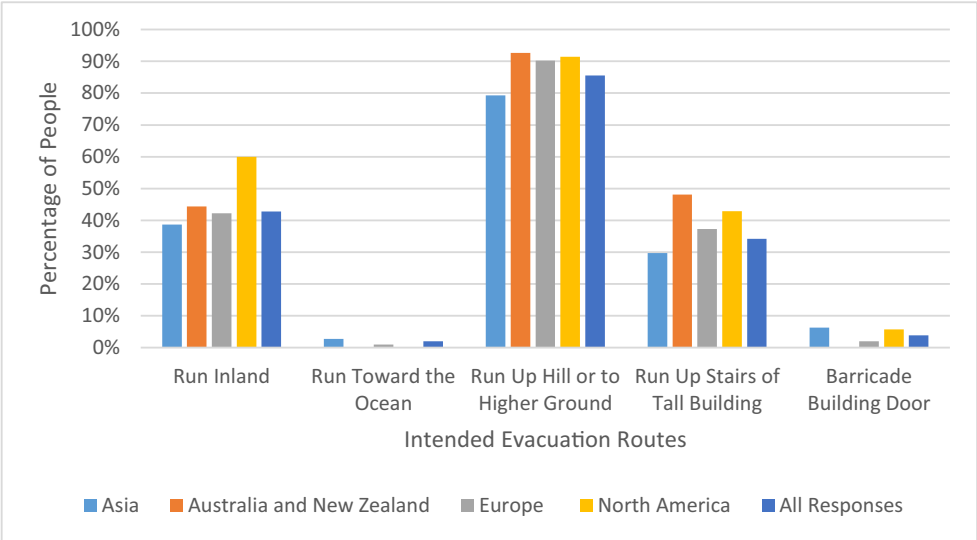


Fig. 6 Evacuation intentions

ripples - rises and falls in water level - with no distinguishable wave. Further research is necessary to consider if misrepresentations of what a tsunami looks like leads to misconceptions and failure of intent to evacuate.

Many participants had misconceptions about tsunami causes. The majority of participants identified earthquakes as a cause of tsunami; however, this left 15.8% of the sample not knowing that earthquakes cause tsunamis. Although it was encouraging that a high percentage of tourists believed earthquakes could cause tsunamis, in our sample only about ¾ of Asians believed this (the majority of which were from India in our sample). Nearly one in four survey participants incorrectly believed storms caused tsunamis. More than one in five participants mistakenly believed global warming can cause

Table 2 Percentage of respondent's beliefs about tsunami cause and evacuation intentions

Region*	Asia $N = 111$	Australia & N. Zealand $N = 27$	Europe $N = 102$	N. America $N = 35$	All responses $N = 304$
Which of the following could generate a tsunami? %					
Landslide	22.5	25.9	41.2	25.7	28.6
Severe storm	20.7	22.2	23.5	40.0	24.7
Global warming	22.5	22.2	21.6	22.9	22.0
Lunar gravitational pull	16.2	14.8	8.8	14.3	12.8
Earthquake	76.6	100.0	90.2	94.3	84.2
Volcanic eruption	36.0	66.7	49.0	57.1	46.4
Typhoon	20.7	11.1	22.6	25.7	21.1
Meteor	20.7	25.9	41.2	42.9	31.6
Extreme temperatures	10.8	0	6.9	17.1	8.2
In Indonesia, after a tsunami is generated near you, how long do you think you would typically have to evacuate? %					
<30 min	56.8	66.7	61.8	42.9	56.3
30 min-1 h.	20.7	14.8	24.5	31.4	25.3
1–2 h.	13.5	14.8	8.8	14.3	11.2
2–3 h.	6.3	3.7	5.9	8.6	5.6
What would you do if a tsunami was coming? Check all that apply. %					
Run inland	38.7	44.4	42.2	60.0	42.8
Run towards the ocean	2.7	0	1.0	0	2.0
Run up a hill or to higher ground	79.3	92.6	90.2	91.4	85.5
Run up the stairs of tall building	29.7	48.1	37.3	42.9	34.2
Barricade building door	6.3	0	2.0	5.7	3.9

*Regions do not add up to 304 because some participants did not fit into these regions, but the sample sizes were too small from these reasons to calculate separately

tsunamis across all world regions analyzed. Although earthquakes were generally seen as being able to cause a tsunami, more research should be done on the type of earthquakes tourists believe are likely to cause tsunamis (e.g. perceptions of strength and duration of earthquake needed to generate a tsunami) and under what circumstances they would self-evacuate (e.g. self evacuation after earthquake vs. hearing siren). It is unclear how many of those who understand that earthquakes cause tsunamis know that the earthquake itself is a natural warning that a tsunami may be approaching, and that they should take action on their own. Many tourists are unaware of the alarm system in Bali, and many would be out of earshot if an alarm were to sound.

While more than half (56.3%) of participants believed they had <30 min to evacuate, this left 42.1% of participants believing they had more than 30 min to evacuate. Our models showed a tsunami reaching Kuta (and other beach resorts) around 20 min after the start of earthquake shaking. This perceived lack of urgency could cause unnecessary loss of life. Tourists should be educated about immediate evacuation after an earthquake strikes, including evacuation strategies if they are at or near their hotel.

Participants, in general, had intentions of evacuating up or inland in the event of a tsunami. 85.5% of participants said they would run up a hill or to higher ground if a tsunami were approaching, however the geography of the Kuta area in particular with lack of hills would make this difficult if not impossible for tourists depending on where they are at the time of the earthquake. 42.8% of respondents reported they would run inland, which is the best evacuation strategy for most of Denpasar where there are no four-story buildings. South of Denpasar the peninsula narrows and is not wide enough for inland evacuations (See Fig. 2). This part of the city is where vertical evacuation sites are needed if individuals are to safely evacuate. Only 34.2% of respondents reported that they would run up the stairs of a tall building.

However, Bali faces another challenge in that, even if it had widespread tsunami hazard understanding and a flawless tsunami warning system, there is currently no feasible way for some people to evacuate to high ground in time during a worst-case tsunami scenario in some high-tourist areas of Bali. Thus, without significant tsunami infrastructure development such as the building of Temporary Evacuation Shelters, many casualties are expected. The lack of a vertical evacuation shelter and tall buildings in high traffic tourists areas in Kuta mixed with cultural beliefs and regulations about building height would make this a challenge depending on where the tourist was located when the earthquake occurred. These difficulties make it important for tourists to know the specific locations of buildings in their area higher than 20 meters and how to get there well before a tsunami strikes. In the event that no tall buildings are within reach, tourists should seek shelter in the highest place they can find.

Survey limitations and additional research

Surveys were conducted in English, Chinese, and Japanese since these languages represented the largest number of tourists to Bali, but tourists who did not speak any of these languages were unable to participate. The diverse number of countries represented by survey participants is both a limitation and strength of the data. Although 40 countries are represented by the survey, India had the largest number of respondents ($N = 33$). There were 24 countries represented in the survey with less than five respondents each. Some world regions had over 100 participants in the sub-analysis while others, such as African countries, had much fewer. This limited our ability to perform statistically convincing sub-analyses across countries and regions.

It is likely that the location in which the survey was conducted contributed to an overrepresentation of respondents from particular countries. For example, Indian and American respondents formed a larger percentage of the survey sample when compared to Bali's typical tourism demographics, likely because surveys were distributed at the Uluwatu Kecak Dance and those distributing the surveys were American and Indonesian. Tourists from Australia who primarily come to Bali for the nightlife and beaches may be underrepresented as a result.

Additional research is suggested for tourist knowledge of tsunami natural warning signs such as receding oceans and tourist perceptions of what type of earthquake (e.g. strong vs. weak shaking) can cause a tsunami.

Recommendations

Bali has done much to address the issue of becoming better prepared for tsunamis, yet there are additional actions needed to prevent disaster. Local efforts have included Tsunami Ready certificates from an Indonesian-based company that advises, trains, and certifies hotels on tsunami preparedness (Tsunami Ready). The preparedness arm of Bali's government was recently tasked with issuing Natural Disaster Ready Certificates (including tsunamis). Requirements for the government issued certificate include a safe assembly point, access (with direction signs) to the assembly point, and stored water and food at the assembly point. Between 2013 and 2017, only forty of the thousands of hotels in Bali were awarded the Natural Disaster Ready Certificate. Sideman (2017) recommends improved coordination between the Bali Tourism Board (which includes the Hotel association), the Tour Guide Association (HPI) and the Association of Recreational Parks (PUTRI) to prepare hotels to be ready for tsunamis. Our study also demonstrates the importance of tourist education and ensuring there are safe and well-marked locations for evacuation in high tourist areas.

According to our study, tourist education is an important component of disaster mitigation efforts. If tourists wait for government sirens or hotel staff to sound the alert it may be too late. We feel that one of the greatest weaknesses in the tsunami disaster mitigation in Indonesia is reliance on a warning from the government before anyone takes action (Hall et al. 2017). Specifically, it is important to "socialize the population with natural tsunami warning signs" (Wegscheider et al. 2011, p. 255). Recommendations include posting informational signs at points of entry (e.g. ferry terminals and the airport) and posted signs and brochures at each hotel, hostel, or homestay. At minimum this information should include natural tsunami warning signs (e.g. earth shaking even if not intense, receding ocean) and knowledge of the 20/20/20 principle (> 20 seconds of shaking, immediate vertical self-evacuation as a tsunami may arrive in 10–20 minutes, and vertical evacuation of at least 20 meters (Hall et al. 2017).

In addition, all tourist accommodations should have posted information about routes and destinations for evacuations and a generalized map showing the evacuation route whether up in the hotel, to a nearby hill if available, or out and inland to a specified tall building (e.g. other hotel, shopping mall, TES). Evacuation brochures were previously created in cooperation with the German Organization for Technical Cooperation–International Services (GTZ IS). These brochures (Tsunami Ready) for Sanur and Kuta include evacuation maps, routes, procedures, and public shelters. These brochures could be updated and made readily available to tourists by accommodation providers.

It is advisable that hotel guests know exactly where to directly go in an evacuation and that they not be expected to wait at a hotel gathering place for a staff member to guide them. Waiting at gathering places (*tempat kumpul*) will waste precious minutes needed to get to safety. Hotel employees including beach lifeguards should be trained to know the 20-20-20 rule and practice evacuation routes so that they can alert and help tourists. Hotels, particularly those that serve as vertical evacuation sites, should also have emergency supplies such as first aid kits and water available.

While increasing tourist knowledge of tsunami risk, warning signs, and recommended evacuation behaviors is praiseworthy, it will do little to prevent disaster if there are no hills or structures nearby for safe evacuation. In high-tourism areas in Bali such as Kuta, where terrain is fairly flat and large tourist events occur on a narrow neck of land, evacuation would be difficult to impossible despite the presence of a siren, correct position of evacuation signage, and the best efforts to educate tourists about natural warning signs and evacuation protocol.

In recent years, Indonesia has begun building Temporary Evacuation Shelters in tsunami prone areas. These cement shelters are five stories high with the bottom three stories being an open atrium (used as a market or recreation area) with wide stairways and ramps on either end to quickly move people up to the wide-open top two floors. So far only one TES has been built on Bali. It is on the flat and vulnerable island of Serangan just south of Sanur. This shelter sits in the middle of a village and is the designated gathering place for several schools, but it is removed from any of the main tourist areas. There is great need to build more governmental vertical evacuation buildings in beach resort areas (Strunz et al. 2011). The creation of inundation maps for high-tourist areas, overlaying evacuation areas (e.g. hills, hotels suitable for evacuation) on these maps, and identifying locations within the inundation zone without suitable evacuation sites is essential. Existing buildings tall and sturdy enough for evacuation (e.g. certain hotels, malls) should be marked and evacuation signs pointing to these structures should label the destination.

Since there are only a limited amount of buildings tall enough (mostly hotels) in the beach areas of southern Bali, it is recommended that beach resort cities like Jimbaran, Kuta, Legian, Seminyak, Nusa Dua and Sanur all build Temporary Evacuation Shelters (TES). Given the high density of land use and the high cost of property, these structures could be cost prohibitive to municipalities. Provincial or national policies might consider adding a tsunami surtax to hotel or airport fees to help pay for these structures. Our informal interviews suggest local cultural and religious obstacles may include the belief that no building should be constructed to a height greater than that of Hindu temples in the region and that many Balinese believe that their religious offerings will prevent a tsunami event in Bali. More formal qualitative research is needed to determine the extent to which these beliefs exist and how these beliefs impact the local government's ability to construct additional TES in Bali.

Lastly, as Indonesian tourism rapidly expands beyond Bali, preventative efforts should be undertaken to ensure tourism does not worsen the death toll in the event of a future tsunami. For example, large resort developments are currently underway in Lombok. Care should be taken that international tourism developers and government officials understand and carefully consider the impact that depletion of natural tsunami barriers may have on the local population and tourists in the event of a tsunami. Strategic plans to preserve natural mangrove forests and coral reefs should be key components of this effort.

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References

Bali Government Tourism Office (4 April 2018a) The number of foreign tourist arrivals to Bali by month. Available via http://www.disparda.baliprov.go.id/en/Statistics2. Cited April 16 2018

Bali Government Tourism Office (4 April 2018b) Accommodations in Bali by regency. Available via http://www.disparda.baliprov.go.id/en/Statistics2. Cited April 16 2018

Becken S, Mahon R, Rennie HG, Shakeela A (2014) The tourism disaster vulnerability framework: an application to tourism in small island destinations. Nat Hazards 71(1):955–972

Cox D (2001) The inappropriate tsunami icon. Science of Tsunami Hazards 19:87–92

Dash N, Gladwin H (2007) Evacuation decision making and behavioral responses: individual and household. Nat Hazards Rev 8(3):69–77

Drabek TE (1995a) Disaster responses within the tourist industry. Int J Mass Emerg Disasters 13(1):7–23

Drabek TE (1995b) Disaster planning and response by tourist business executives. Cornell Hotel Restaur Admin Q 36(3):86–96

Drabek TE (2000) Disaster evacuations: tourist-business managers rarely act as customers expect. Cornell Hotel Restaur Admin Q 41(4):48–57

Esteban M, Tsimopoulou V, Mikami T, Yun NY, Suppasri A, Shibayama T (2013) Recent tsunamis events and preparedness: development of tsunami awareness in Indonesia, Chile and Japan. Int J Disast Risk Re 5:84–97

European Commission, Joint Research Centre, Columbia University & Center for International Earth Science Information Network (2015, January 12) GHS population grid, derived from GPW4, multitemporal (2015). Available via http://data.europa.eu/89h/jrc-ghsl-ghs_pop_gpw4_globe_r2015a. Cited April 17, 2018

Faulkner B (2001) Towards a framework for tourism disaster management. Tour Manag 22(2):135–147

Faulkner B, Vikulov S (2001) Katherine, washed out one day, back on track the next: a post-mortem of a tourism disaster. Tour Manag 22(4):331–344

Fraser S, Leonard G, Johnston DM (2013) Intended evacuation behaviour in a local earthquake and tsunami at Napier, New Zealand. GNS Science

Gaughan AE, Stevens FR, Linard C, Jia P, Tatem AJ (2013) High resolution population distribution maps for Southeast Asia in 2010 and 2015. PLoS One 8(2):e55882. https://doi.org/10.1371/journal.pone.0055882

Geofisika BMKD (2010) InaTEWS, Indonesia tsunami early warning system. Konsep dan Implementasi

Hall S, Pettersson J, Meservy W, Harris R, Agustinawati D, Olson J, McFarlane A (2017) Awareness of tsunami natural warning signs and intended evacuation behaviors in Java, Indonesia. Nat Hazards 89(1):473–496

Hamzah L, Puspito NT, Imamura F (2000) Tsunami catalog and zones in Indonesia. J Nat Disaster Sci 22(1):25–43

Harris R, Major J (2016) Waves of destruction in the east indies: the Wichmann catalogue of earthquakes and tsunami in the Indonesian region from 1538 to 1877. Geol Soc Lond, Spec Publ 441(1):9–46

Harris RA, Prasetyadi C (2002) Who's next? Assessing vulnerability to geophysical hazards in densely populated regions of Indonesia. Bridges 2:14–17

Hystad PW, Keller PC (2008) Towards a destination tourism disaster management framework: long-term lessons from a forest fire disaster. Tour Manag 29(1):151–162

Johnston D, Becker J, Gregg C, Houghton B, Paton D, Leonard G, Garside R (2007) Developing warning and disaster response capacity in the tourism sector in coastal Washington, USA. Disaster Prev Manag 16(2):210–216

Kelman I, Spence R, Palmer J, Petal M, Saito K (2008) Tourists and disasters: lessons from the 26 December 2004 tsunamis. J Coast Conserv 12(3):105–113

Lay T, Kanamori H, Ammon CJ, Nettles M, Ward SN, Aster RC, … DeShon HR (2005) The great Sumatra-Andaman earthquake of 26 December 2004. Science 308(5725):1127–1133

Liu ZY, Harris RA (2013) Discovery of possible mega-thrust earthquake along the Seram trough from records of 1629 tsunami in eastern Indonesian region. Nat Hazards 72(3):1311–1328

Løvholt F, Setiadi NJ, Birkmann J, Harbitz CB, Bach C, Fernando N, … Nadim F (2014) Tsunami risk reduction–are we better prepared today than in 2004? Int J Disast Risk Re 10:127–142

Meheux K, Parker E (2006) Tourist sector perceptions of natural hazards in Vanuatu and the implications for a small island developing state. Tour Manag 27(1):69–85

Muck M (2008) Tsunami evacuation modeling: development and application of a spatial information system supporting tsunami evacuation planning in south-West Bali. Institut fur Geographie an der Universitat Regensburg, Regensburg

Murphy PE, Bayley R (1989) Tourism and disaster planning. Geographical Review, 36-46. Available via http://www.tsunamiready.com/resources/index.php

Niman MI (2010) The political tsunami: not all death and destruction is natural. Tsunami Communication:(Inter) personal/intercultural, Media, Technical, Ethical, Philanthropic, Development, and Personal Responses, pp 85–99

Nurhayati D (2017) Bali declared world's top destination for 2017. Jakarta Post, April 24 2018. Available via http://www.thejakartapost.com/travel/2017/04/24/bali-declared-worlds-top-destination-for-2017.html. Cited April 29 2018

Orchiston C (2013) Tourism business preparedness, resilience and disaster planning in a region of high seismic risk: the case of the southern Alps, New Zealand. Curr Issue Tour 16(5):477–494

Paris N (2017) Why Bali is the greatest destination on earth (so says Trip Advisor). The Telegraph. March 27. Available via http://www.telegraph.co.uk/travel/news/bali-named-best-tourist-destination/. Cited April 29 2018

Plautz J (2016, December 16) 'Where is Bali?' and more most-Googled travel questions in 2016. Travel + Leisure. Available via http://www.travelandleisure.com. Cited 23 April 2018

Post J, Wegscheider S, Mück M, Zosseder K, Kiefl R, Steinmetz T, Strunz G (2009) Assessment of human immediate response capability related to tsunami threats in Indonesia at a sub-national scale. Nat Hazards Earth Syst Sci 9(4):1075–1086

Ritchie BW, Bentley G, Koruth T, Wang J (2011) Proactive crisis planning: lessons for the accommodation industry. Scand J Hosp Tour 11(3):367–386

Rittichainuwat BN (2013) Tourists' and tourism suppliers' perceptions toward crisis management on tsunami. Tour Manag 34:112–121

Rittichainuwat B, Nelson R, Rahmafitria F (2018) Applying the perceived probability of risk and bias toward optimism: implications for travel decisions in the face of natural disasters. Tour Manag 66:221–232

Seville E, Brunsdon D, Dantas A, Le Masurier J, Wilkinson S, Vargo J (2006) Building organisational resilience: a summary of key research findings. Resilient Organisations Programme, University of Canterbury, Christchurch

Shoaf KI, Rottman SJ (2000) The role of public health in disaster preparedness, mitigation, response, and recovery. Prehosp Disaster Med 15(4):18–20

Sideman IBP (2017) Interview August 1, Tanjung Benoa, Bali

Sorooshian S (2005) Meeting the challenges of natural hazards in the wake of the tsunami disaster. EOS Trans AGU 86(2):14. https://doi.org/10.1029/2005EO020005

Spahn H, Hoppe M, Vidiarina HD, Usdianto B (2010) Experience from three years of local capacity development for tsunami early warning in Indonesia: challenges, lessons and the way ahead. Nat Hazards Earth Syst Sci 10(7):1411–1429

Strunz G, Post J, Zosseder K, Wegscheider S, Mück M, Riedlinger T, … Harjono H(2011) Tsunami risk assessment in Indonesia. Nat Hazards Earth Syst Sci 11(1):67–82

Sullivan HT, Häkkinen MT (2006) Disaster preparedness for vulnerable populations: determining effective strategies for communicating risk, warning, and response. In: Third annual Magrann research conference at Rutgers University, vol 4, pp 21–04

Suppasri A, Goto K, Muhari A, Ranasinghe P, Riyaz M, Affan M, … Imamura F (2015) A decade after the 2004 Indian Ocean tsunami: the progress in disaster preparedness and future challenges in Indonesia, Sri Lanka, Thailand and the Maldives. Pure Appl Geophys 172(12):3313–3341

Titov VV, Moore CW, Greenslade DJ, Pattiaratchi C, Badal R, Synolakis CE, Kanoglu U (2011) New tool for inundation modeling: community modeling interface for tsunamis (ComMIT). Pure Appl Geophys 168:2121–2131

Virapart C (2011) Tsunami prevention and preparedness practices for tourism sector and private entrepreneur in Khao Lak, Phang Nga Province of Thailand. J Coast Res:365–368

Wegscheider S, Post J, Zosseder K, Mück M, Strunz G, Riedlinger T, … Anwar HZ (2011) Generating tsunami risk knowledge at community level as a base for planning and implementation of risk reduction strategies. Nat Hazards Earth Syst Sci 11(2):249–258

WorldPop (October, 2014) Asia [Dataset]. Available via www.worldpop.org. Cited April 17, 2018