

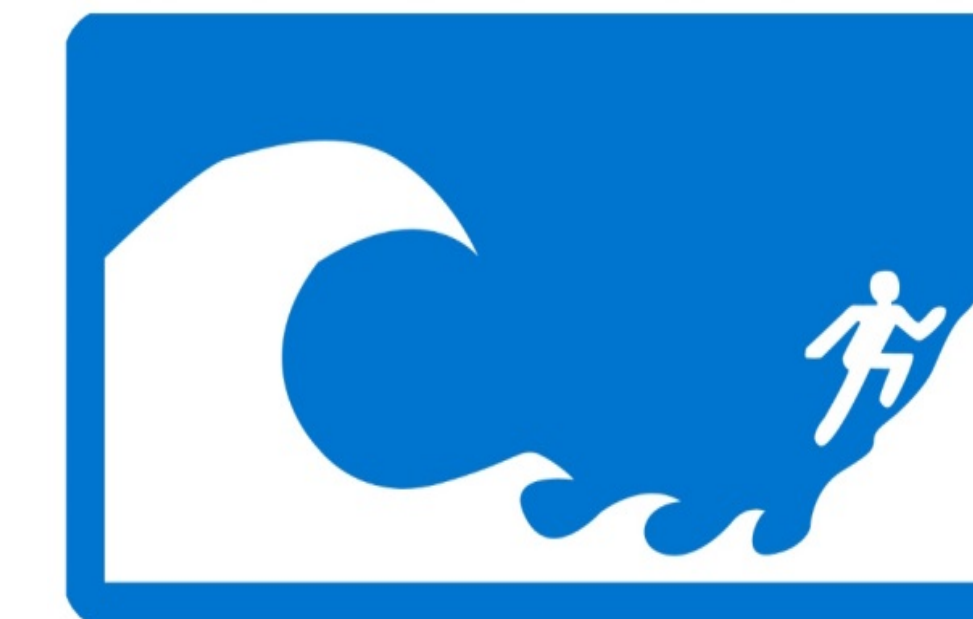
IMPACT OF EARTHQUAKE-INDUCED TSUNAMIS ON PUBLIC HEALTH

Spyridon Mavroulis ⁽¹⁾, Maria Mavrouli ⁽²⁾, Efthymios Lekkas ⁽¹⁾, and Athanassios Tsakris ⁽²⁾

smavroulis@geol.uoa.gr, mmavrouli@med.uoa.gr, elekkas@geol.uoa.gr, atsakris@med.uoa.gr

(1) Department of Dynamic Tectonic Applied Geology, Faculty of Geology and Geoenvironment, School of Sciences, National and Kapodistrian University of Athens, Greece

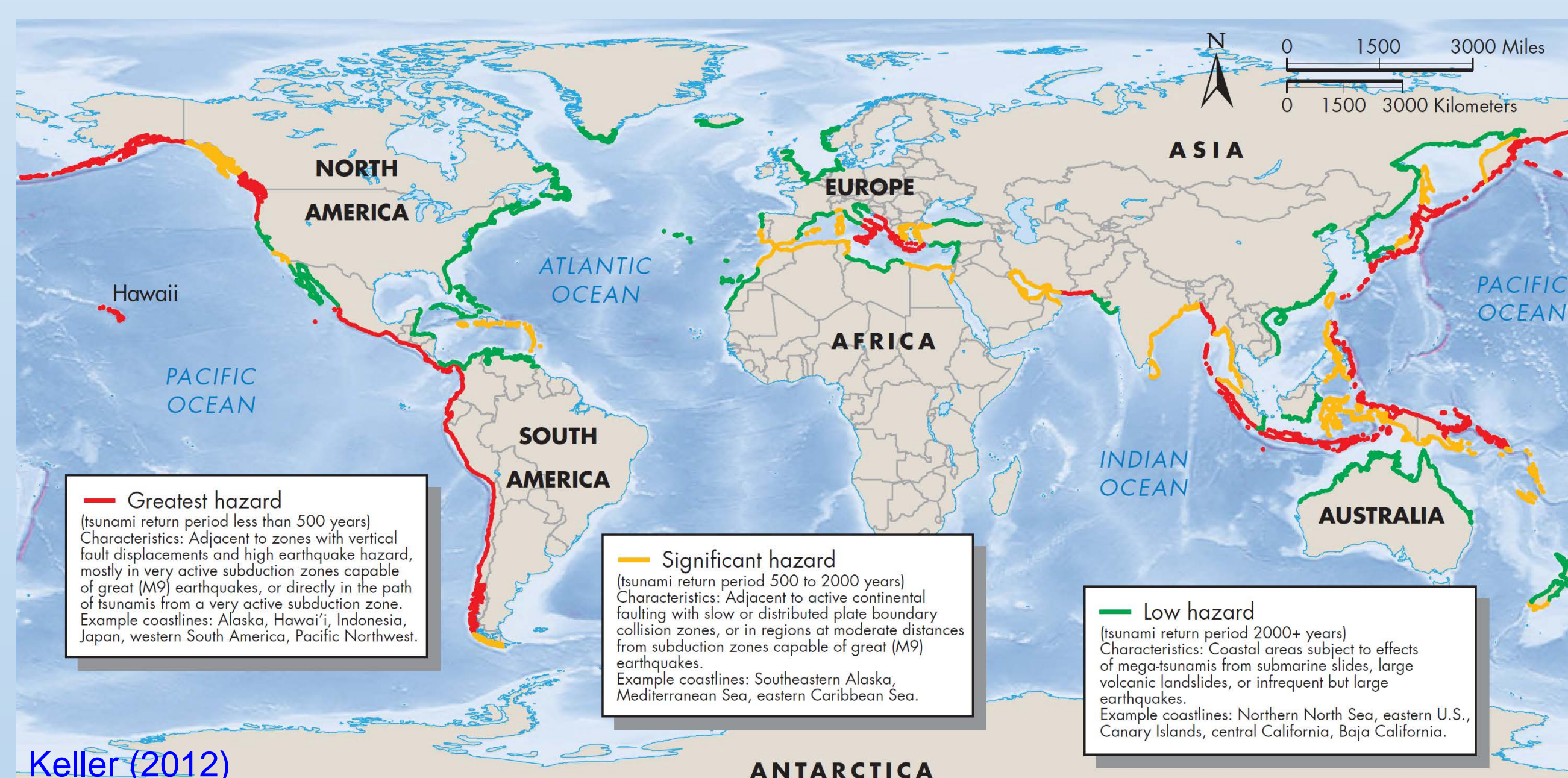
(2) Department of Microbiology, Medical School, National and Kapodistrian University of Athens, Greece



INTRODUCTION

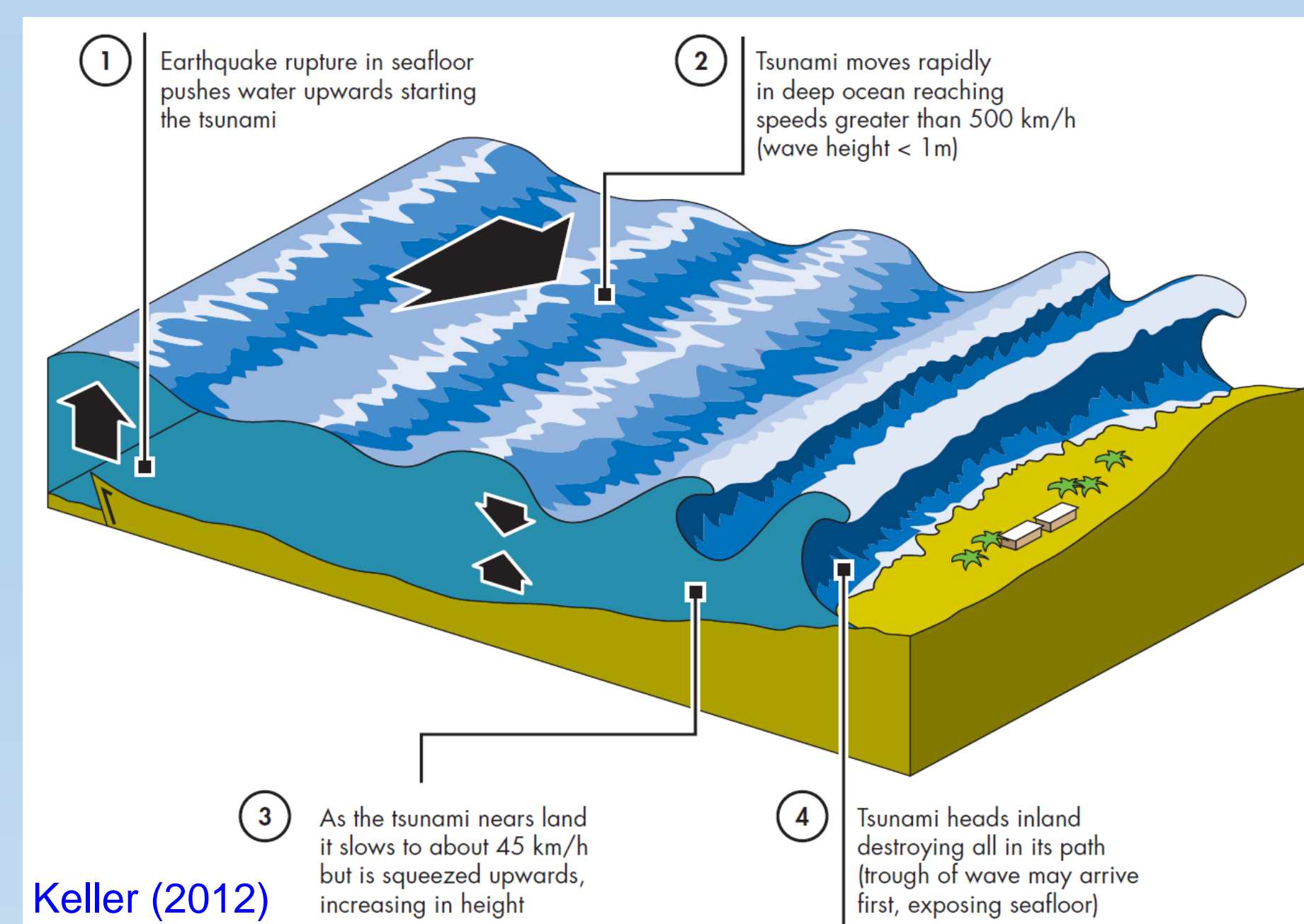
Tsunami is a gravity wave, or series of gravity waves, generated when a large water volume is vertically or horizontally displaced by a sudden disturbance. They are caused by various natural processes comprising earthquakes, surface or submarine landslides, rock avalanches, volcanic eruptions, meteorological disturbances, underwater gas emission and asteroid impacts. They may also be induced by man-made processes including submarine nuclear bomb testing.

The most frequent and well-known source of destructive tsunamis are earthquakes. More than 85% of tsunamis have tectonic causes such as earthquake-induced fault movements, while more than 80% of them have occurred in the Pacific Ocean where transoceanic tsunamis are initiated along ocean trenches by the generation of subduction-zone earthquakes with rupture zones of several hundreds of kilometers.



Keller (2012)

Map of the relative hazard of coastlines to experience a tsunami that is at least 5 m (16 ft) high.



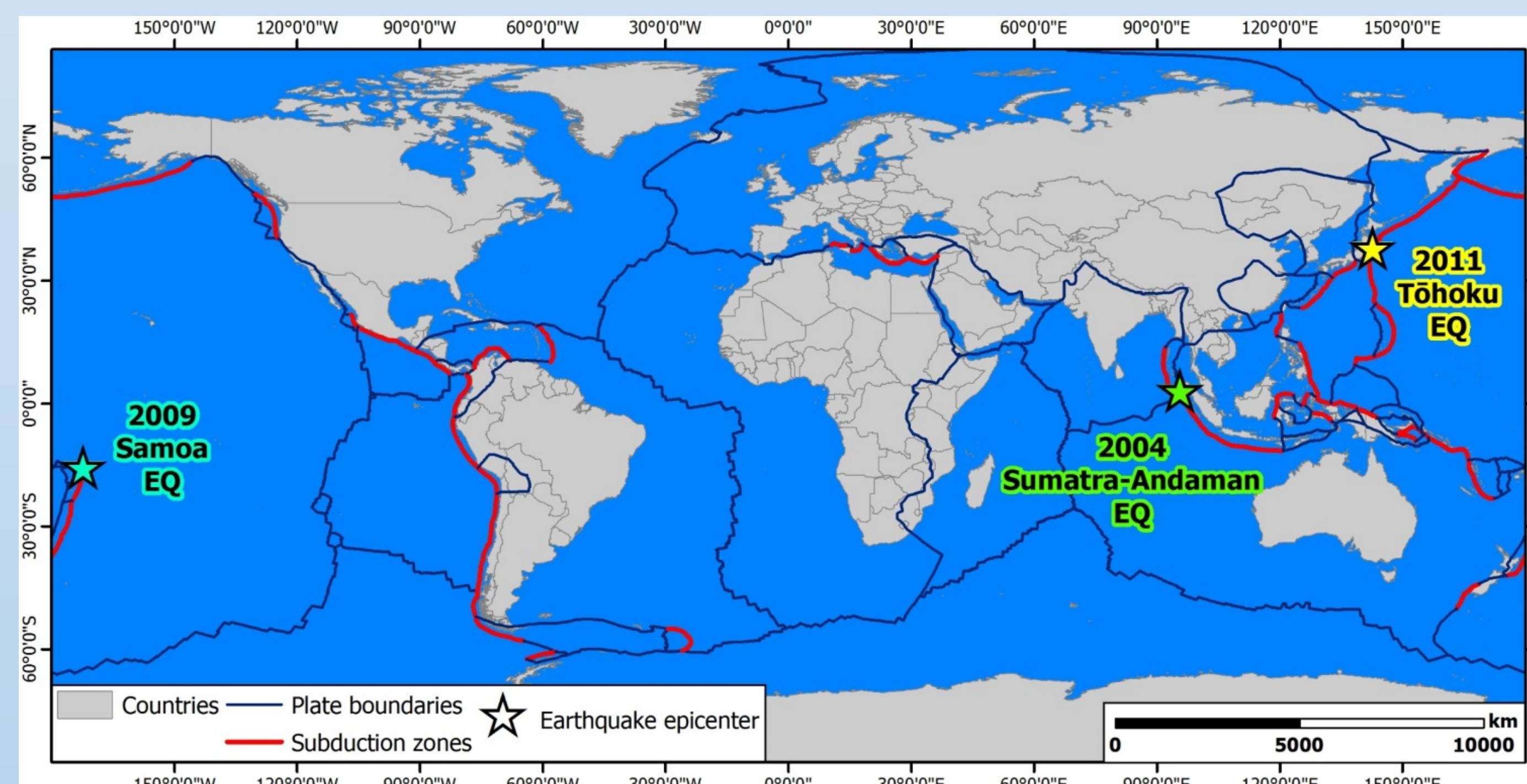
Generation of an earthquake-induced tsunami: Massive amounts of sea water in the form of devastating surface waves traveling hundreds of kilometers per hour have the potential to cause severe damage to coastal infrastructures, loss of life, injuries and emergence of infectious diseases.

METHODOLOGY

This study involved an extensive and systematic literature review of 50 research publications related to public health impact of the three most devastating tsunamis of the last 12 years induced by great earthquakes, namely:

- the **2004 Indian Ocean tsunami** induced by the Mw 9.2, December 26, 2004 Sumatra – Andaman earthquake,
- the **2009 Samoa tsunami** induced by the Mw 8.1, September 29, 2009 Samoa earthquake and
- the **2011 Great East Japan tsunami** induced by the Mw 9.0, March 11, 2011 Tōhoku (Japan) earthquake.

The inclusion criteria were literature type comprising journal articles and official reports, natural disaster type including tsunamis generated only by earthquakes, population type including humans, and outcome measure characterized by infectious disease (ID) incidence increase.



POTENTIAL INFECTIOUS DISEASES FOLLOWING EARTHQUAKE-INDUCED TSUNAMIS

The potential post-tsunami ID are classified into 11 groups including respiratory, pulmonary, wound-related, water-borne, skin, vector-borne, eye, fecal-oral, food-borne, fungal and mite-borne ID. Respiratory infections were detected after all the above mentioned tsunamis. Wound-related, skin and water-borne ID were observed after the 2004 and 2011 tsunamis, while vector-borne, fecal-oral and eye ID were observed only after the 2004 tsunami and pulmonary, food-borne, fungal and mite-borne ID were diagnosed only after the 2011 tsunami. Tetanus and pneumonia are the deadliest post-tsunami ID.

VULNERABLE AGE AND GENDER POPULATION GROUPS

Based on available age and gender data, it is concluded that the most vulnerable population groups are males, children (age ≤ 15 years) and adults (age ≥ 65 years).

RISK FACTORS FOR DISEASE EMERGENCE & DISEASE INCIDENCE INCREASE

The detected risk factors include (1) lowest socioeconomic conditions, poorly constructed buildings and lack of prevention measures, (2) lack of awareness and prior warning resulting in little time for preparedness or evacuation, (3) severely injured tsunami survivors exposed to high pathogen densities in soil and water, (4) destruction of critical infrastructures (health care systems) causing delayed management and treatment of severe cases, (5) aggravating post-tsunami weather conditions, (6) formation of extensive potential vector breeding sites due to flooding, (7) overcrowded conditions in evacuation shelters, (8) low vaccination coverage, (9) poor personal hygiene, (10) minimum precautions against food contamination and (11) dependency of young children and weaker physical strength of elders.

TYPES OF INFECTIOUS DISEASES FOLLOWING EARTHQUAKE-INDUCED TSUNAMIS			
Types of infectious diseases	2004 Indian Ocean tsunami	2009 Samoa tsunami	2011 Great East Japan tsunami
Respiratory infections	✓	✓	✓
Pulmonary infections	×	×	✓
Wound-related infections	✓	×	✓
Water-borne infections	✓	×	✓
Skin infections	✓	×	✓
Vector-borne infections	✓	×	×
Eye infections	✓	×	×
Fecal-oral infections	✓	×	×
Food-borne infections	×	×	✓
Fungal infections	×	×	✓
Mite-borne infections	×	×	✓

CONCLUSIONS

Our study referred to potential ID following tsunamis induced after great earthquakes during the last 12 years. The establishment of strong disaster preparedness plans characterized by adequate environmental planning, resistant infrastructures and resilient health facilities is significant for the early detection, surveillance and control of emerging ID. Moreover, the establishment and the unceasing function of reliable early warning systems may help mitigate tsunami-related impact on public health.