

Natural disaster-induced environmental migration from the Indian subcontinent resulting in malaria outbreak in Greece

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Extreme hydrometeorological disasters such as floods and hurricanes can severely damage human life, natural and built environment and economic development. Consequently, they can result in environmental migration (EM). In case of infectious disease (ID) outbreaks during the post-disaster period and subsequent EM, environmental refugees from endemic regions serve as ID carriers to their new residence sites altering the spatial ID distribution and incidence. The continuous massive influx of environmental refugees from malaria endemic regions to non-endemic ones can build up a parasite reservoir among naive host populations.

Initially, serum specimens were collected in 2012 from asymptomatic individuals, 298 Greeks and 721 immigrants residing in areas of documented local malaria transmission in Laconia (Southern Peloponnese) and in Eastern Attica, Greece. Sera were tested for antibodies against *Plasmodium vivax* and *P. falciparum* using the Malaria-Ab ELISA (IBL International GMBH, Hamburg, Germany). Taking into account that Greece has been declared malaria free by the WHO since 1974, we conducted an extensive and systematic literature review related to natural disasters leading among others to increased malaria risk in Indian Subcontinent and respective forced EM in order to detect relative possible causes of reintroduction and localized outbreaks of malaria in Greece.

Regarding the country of origin, information was available for 685 (95%) of the 721 immigrants. Of the 678 immigrants from Indian Subcontinent, 627 (92.5%) originated from Pakistan, 24 (3.53%) Afghanistan, 24 (3.53%) India and 3 (0.44%) Bangladesh. Of the 721 immigrants, 582 and 124 resided in Laconia and Eastern Attica respectively. Seventy-one immigrants residing in Laconia and 14 in Eastern Attica were positive for antimalarial antibodies, while none of the 298 Greeks residing in Laconia (N=248) and Attica (N=50) was found positive. Based on already published scientific data, Pakistan has been exposed to extreme monsoon flooding during 2003, 2007 and 2010-2014, and is ranked 9th in terms of flood affected countries worldwide. In 2010, Pakistan experienced the worst floods recorded in its recent history since approximately 20% of Pakistan's total area inundated and about 20 million people were directly affected by destruction of livelihood, property and infrastructure, with a death toll of about 2000, 37 million medical consultations (acute respiratory infection-23%, skin diseases-11%, acute diarrhea-9%, suspected malaria-6%) and over 10 million internal and international environmental refugees.

In conclusion, Greece has been declared malaria free since 1974. However, an increase in cases of *P. vivax* malaria has been detected since 2009. Since immigrants originate mostly from Pakistan, reasons for this increase may include the forced EM induced by the 2010 and subsequent Pakistan floods that led to increased malaria cases in Indian subcontinent, surges of environmental refugees from these malaria endemic flood-affected regions and the existence of permissive *Anopheles* vectors in Greece.