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Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Medicine

journal homepage: http://ees.elsevier.com/apjtm

Original research http://dx.doi.org/10.1016/j.apjtm.2016.07.033

Meteorological influences on dengue transmission in Pakistan

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ARTICLE INFO

Article history:
Received 18 May 2016
Received in revised form 19 Jun 2016
Accepted 18 Jul 2016
Available online xxx

Keywords:
Dengue fever
Pakistan
Climate
IOD
NINO 3.4

ABSTRACT

Objective: To identify the influences of local and regional climate phenomena on dengue transmission in Lahore District of Pakistan, from 2006 to 2014.

Methods: Time-series models were applied to analyze associations between reported cases of dengue and climatic parameters. The coherence trend of regional climate phenomena (IOD and ENSO) was evaluated with wavelet analysis.

Results: The minimum temperature 4 months before the dengue outbreak played the most important role in the Lahore District (P = 0.03). A NINO 3.4 index 9 months before the outbreaks exhibited a significant negative effect on dengue transmission (P = 0.02). The IOD exhibited a synchronized pattern with dengue outbreak from 2010 to 2012. The ENSO effect (NINO 3.4 index) might have played a more important role after 2012.

Conclusions: This study provides preliminary results of climate influences on dengue transmission in the Lahore District of Pakistan. An increasing dengue transmission risk accompanied by frequent climate changes should be noted. Integrating the influences of climate variability into disease prevention strategies should be considered by public health authorities.

1. Introduction

Dengue fever is one of the most prevalent vector-borne diseases in tropical and sub-tropical regions. Dengue virus (DENV) is mainly transmitted by two species of *Aedes* mosquito: *Aedes aegypti* (*A. aegypti*) as the major vector and *Aedes albopictus* (*A. albopictus*) as the secondary vector [1]. DENV has been classified into four serologically distinct types (DEN-I, DEN-II, DEN-III, and DEN-IV), which can cause flu-like clinical outcomes, including fever, headache, muscle and joint pain, or retro-orbital pain [2]. Type-specific antibodies can be produced against infection by the same serotype of DENV; however, severe dengue hemorrhagic fever and dengue shock syndrome mediated by an antibody-dependent enhancement mechanism might occur if subsequent infection is caused by different serotypes [3].

The disease burden of dengue has increased dramatically since 1970, and recent estimates indicate 390 million infections annually and approximately 100 million people with clinical symptoms [4]. Dengue fever is dominant in Latin America, South-East Asia, and Pacific Asia; however, countries in South Asia, including Pakistan, India, and Bangladesh, have also reported an increasing number of outbreaks and brought significant impacts on public heath [4–6].

The ecological changes in dengue transmission are attributable to multifactorial causes with complicated interactions. *A. aegypti* and *A. albopictus* are well-adapted to urban

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Peer review under responsibility of Hainan Medical College.

Foundation Project: This study was funded by the Ministry of Science and Technology, Taiwan (MOST 104-2119-M-038-002) and the Taipei Medical University (TMU101-AE1-B62).

Please cite this article in press as: Atique S, et al., Meteorological influences on dengue transmission in Pakistan, Asian Pacific Journal of Tropical Medicine (2016), http://dx.doi.org/10.1016/j.apjtm.2016.07.033

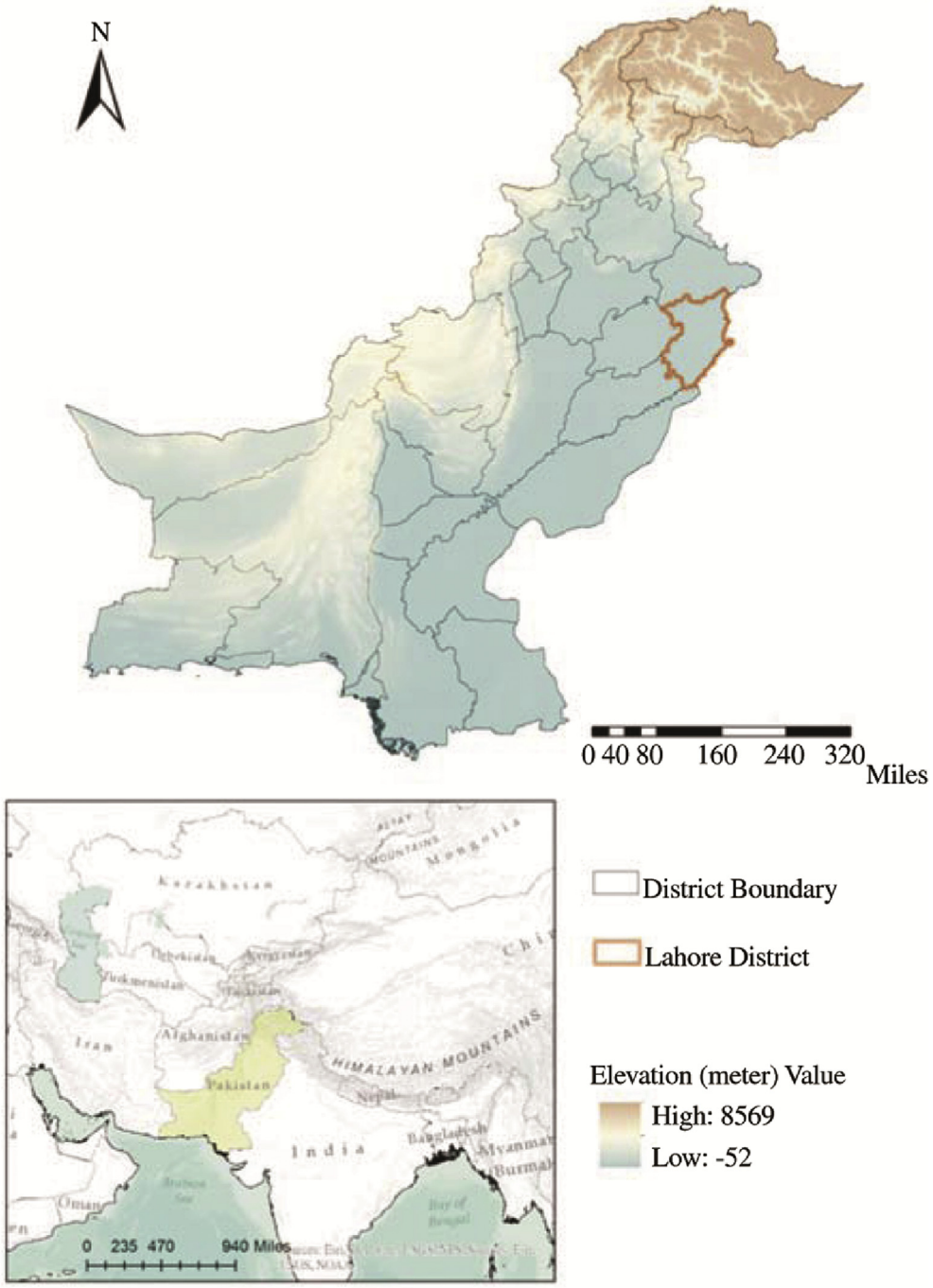

Figure 1. Location of the Lahore District, Pakistan.
The elevation map of Pakistan was acquired from ASTER Global Digital Elevation Map Version 2.

environments; thus, the urbanization triggered by economic development may create more artificial breeding sites preferred by disease vectors [7–9]. Globalization accompanied with frequent international and domestic traveling also enhances the transmission probability of dengue [10,11]. Climate is another important driver, and diverse interactions have been reported among local meteorological parameters (temperature, precipitation, and humidity) and vector population dynamics, virus circulation, and transmission probability [12–14].

More frequently, regional climate changes can cause extreme weather conditions that might influence dengue transmission. The El Niño Southern Oscillation (ENSO) effect is a widely known phenomenon of climate change and is related to the rising sea surface temperature across the tropical Pacific Ocean in 2–7 year cycles [15]. ENSO typically causes regional climate turbulence associated with heavy rainfall and temperature anomalies; however, there is substantial uncertainty regarding the future prediction of these effects [16]. Different synchronized patterns between ENSO and dengue outbreaks have been reported in many studies [17–19]. The Indian Ocean Dipole (IOD) is another ENSO-like climate phenomenon that occurs in the Indian Ocean [20]. Recent studies have demonstrated associations between the IOD and malaria in eastern Africa and dengue in Bangladesh [21,22].

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