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Letter to the Editor

A quick prediction tool for Dengue fever: A timely response is essential!

Dear Editor,

We have read the study by Suleman Atique et al. entitled "Investigating spatio-temporal distribution and diffusion patterns of the dengue outbreak in Swat, Pakistan." The authors of this article established the spatial and temporal clustering and dissemination patterns of the dengue epidemic in the Swat district of Khyber Pakhtunkhwa (KP) province [1]. The infectious disease is one of main worldwide dilemmas, accounting for a major part of global morbidity and mortality. The number of dengue fever (DF) cases continues to rise in Pakistan in the wake of an epidemic caused by floods in June 2022. For this purpose, in the current paper, we developed forecasting tools for the rapidly spreading DF in the Peshawar district, KP province, Pakistan to forecast its prevalence in the upcoming days.

DF is a viral infection spread to humans by infected mosquito bites. The infection is mostly transmitted by the Aedes aegypti parasite and, to a lesser extent, by the Aedes albopictus parasite. On 2nd November 2022, 19,327 cases were confirmed and 15 deaths from them were reported according to Integrated Disease Surveillance & Response System (IDSRS), KP province. From 1st January 2021–25 th November 2021, 48906 cases, including 183 deaths, were registered in four provinces: KP, Punjab, Balochistan, Sindh, which were federally controlled ICT, and AJK autonomous regions. KP, a province that shares the borders with Afghanistan, had the second largest cases of DF, with 10,223, making up 21 % of all the cases, and ten deaths occurred [2].

Accurate and reliable prediction of future events is essential in a variety of fields. Choosing the best method for modeling a specific time series is challenging since the performance of the methods depends on both data characteristics and the properties of applied methods. We chose two most widely used time series models for infectious diseases for this paper [3]. An autoregressive integrated moving average (ARIMA) and the Holt exponential smoothing. ARIMA is a generalized form of autoregressive moving average (ARMA). ARIMA is a kind of the linear model for forecasting the upcoming trend based on historical data [4]. Holt's two-parameter model, sometimes known as "linear exponential smoothing," is a major smoothing method for estimating the data with the trend. Holt's model comprises three equations that interact to offer a final prediction. The initial equation is simple for smoothing that adapts the last smoothed value directly based on the trend of the prior period. The next equation revises the trend over time, giving the trend as the change between the latest two smoothed values. Finally, the forecast is generated using the third equation. Holt's model uses two parameters: one for smoothing in general and one for smoothing the trend. The approach is also identified as trend-enhanced exponential smoothing or double exponential smoothing [5,6].

This study predicts the strikes of DF cases in November and the first week of December 2022 in the endemic district of Peshawar, Pakistan, which is the deadliest. The data in this study covers the period from 1st July to 31st October 2022. This study aims to provide authorities with accurate forecasts of the epidemic's peak duration and severity by applying fundamentally significant models and providing insight into the epidemic's transmission patterns. These tools can evaluate the prediction of future medical structure and material requirements of patients in this region.

After a comparison of the two models, the results show that the Holt model performed better for the DF trend. The predicted number of weekly infected cases for upcoming weeks (November and the first week of December 2022) might reach 1769 (CI 95 %: 973–2566) for the Holt method, while 1542 (CI 95 % 292–2719) for the ARIMA [1,1,1] method. Fig. 2 depicts the predicted line increase of the confirmed cases. We evaluated the models' accuracy using R-square and mean absolute error (MAE). Holt's weekly confirmed cases model with MAE (279.42) and R-square (0.647) was validated and adequately forecasted. The map designed through ArcGIS version 10.8, shows the prevalence of DF in the epidemic district of Peshawar, KP in Pakistan (Fig. 1).

The rising number of DF cases might overwhelm Pakistan's poor healthcare infrastructure. Some other key factors also contribute to the rise in infection in Pakistan, i.e., natural disasters, poor socio-economic conditions, and weather conditions. Floods in Pakistan killed 1739 people and caused $14.9 billion in damage and $15.2 billion in economic losses between June 14 and October 20, 2022. Heavy monsoon rains and melting glaciers following a severe heat wave were the direct causes of the floods linked to climate change. The flooding was the worst in the world since the floods in South Asia in 2020, and it was labeled as the worst in the country's history. DF is on the rise as a result of the devastating floods that occurred in June 2020. The creation and execution of preparation plans are essential in preventing DF and other arboviruses and responding to them. Early warning systems, environmental, entomological, epidemiological surveillance, clinical case management, laboratory assistance, environmental controls, risk communication, vector control, and societal mobilization should be all the parts of this purpose [7].

Sustainable solutions to DF management require political leadership to address the objectives of preparation planning and epidemic response successfully. Comprehensive strategies and

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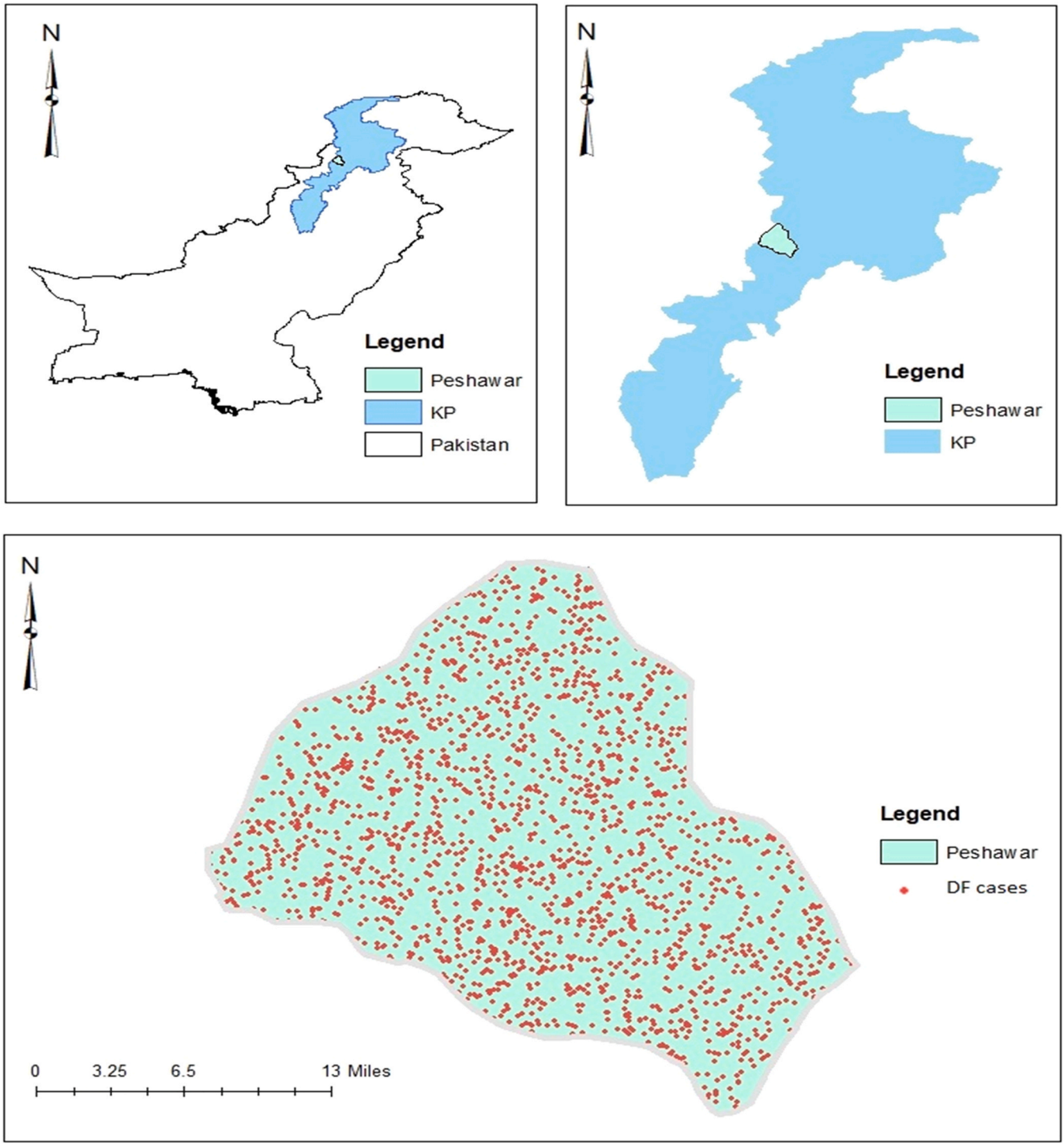

Fig. 1. Study area map.

programs for DF epidemic planning and response need nationwide partnerships comprising governmental organizations, research organizations, and commercial sectors, as well as international cooperation. For example, it could use social media and public places to hold awareness sessions and programs about preventing the virus's spread. If the government takes preventative measures, future occurrence of cases is able to be significantly reduced. The prediction trend for the Peshawar district shows how nasty the infection is; the fast-growing number of cases is not only the worst for this region but also impacts the whole country. This study's findings indicate that DF cases will rapidly increase in the coming weeks. These data can also be used to improve public health advocacy and the type and the scope of government programs to prevent disease spread. Predicting DF cases is important to ensure that Pakistanis with unknown infectious diseases can get sufficient medical cares. The outcomes will be more critical and catastrophic if this will be done in time.

Ethical approval

Permission to conduct the research and collect the data was obtained from the Integrated Vector Control (IVC) program, Health

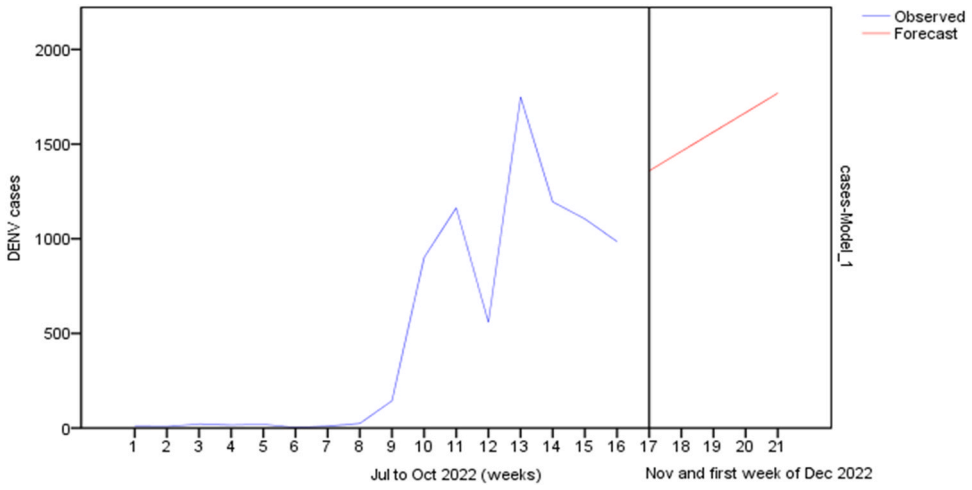

Fig. 2. depicts the predicted lines increase in weekly registered cases by Holt modeling.

Department of Khyber Pakhtunkhwa, Pakistan, and ethical approval for the study was granted by the Institutional Review Board of Hanyang University, Seoul, South Korea.

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CRediT authorship contribution statement

Humera Qureshi: Conceptualization, Visualization, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Muhammad Imran Khan**: Conceptualization, Visualization, Formal analysis, Data curation, Writing – review & editing. **Suk Joo Bae**: Conceptualization, Visualization, Supervision, Writing – review & editing. **Adil Shah**: Writing – original draft, Writing – review & editing.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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