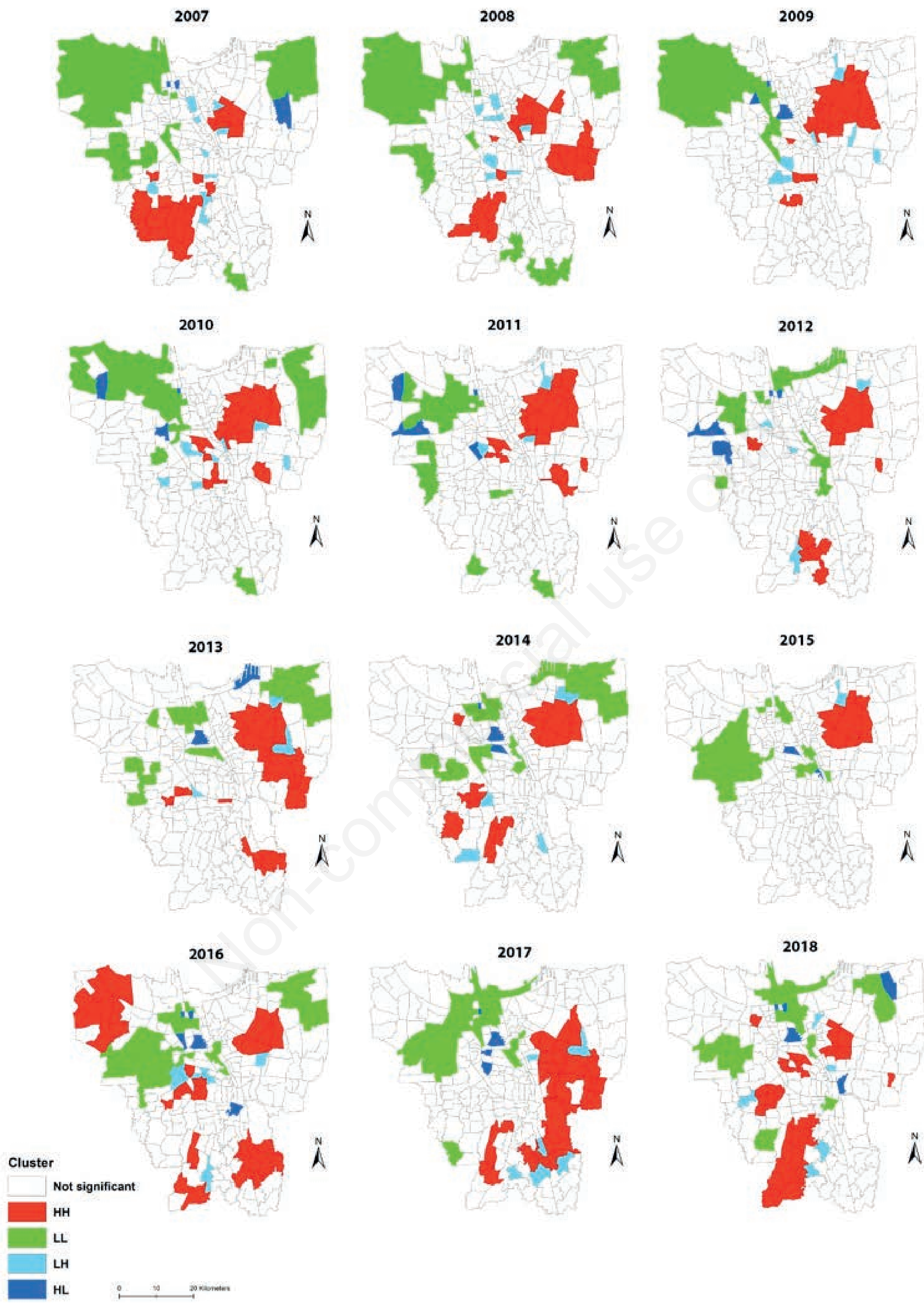

Figure 6. Spatial clusters for dengue fever in Jakarta during 2007 to 2018 as determined by local indicator spatial association analysis.

higher levels of mobility of this population group as it consists of people engaged in productive work. Mobility is a known potential driver associated with pathogens transmission (Pybus *et al*., 2015; Zhu *et al*., 2019; Santos *et al*., 2019). In this study, we used road density as a proxy for mobility. While it is not statistically significantly different, the mean of the road density in high risk clusters was relatively higher than in the low-risk clusters. This finding is consistent with study in China (Qi *et al*., 2015) which found that higher road density is associated with an increased DF risk. In addition, our study found that DF hotspots were common in areas where most people are engaged in service industries compared. We therefore identified age and occupation as the important predictors of clustering.

This study found intriguing evidence that high risk DF areas (*e.g*., Kayu Putih, West Cempaka Putih) have a lower mean population density than those in the low-risk areas. Further, the average number of households in slum was much lower here than in the low-risk clusters. This is inconsistent with the many previous studies showing a positive correlation between DF risk and population density (Schmidt *et al*., 2011; Qi *et al*., 2015; Harapan *et al*., 2020) and poor socioeconomic conditions (Kikuti *et al*., 2015; Aswi *et al*., 2018). Our findings suggest that high DF risk not merely affect impoverished communities but also wealthy populations. It is important to note that inhabitants living in Kayu Putih (a sub-district in Pulo Gadung) have a relatively higher socioeconomic level compared to the surrounding sub-districts (data not shown) and to living in a well-maintained residential area. This finding may be closely linked with environmental and behavioral aspect, especially with regard to how people manage or store water and their yards. In addition, the mere presence of outdoor water bodies (*e.g*., pools and canals) has potential as breeding sites for the mosquitoes (Machault *et al*., 2014). In fact, interventions (*e.g*., routine vector control and monitoring) could not be effectively implemented in this neighborhood due to limited access given by the residents. A strong partnership between local health authorities and stakeholders (*e.g*., local community leaders, property management, private sectors) would be needed to change this situation. In addition, frequent flooding as a result of poor drainage system especially during rainy seasons, could be an environmental driver that maintains the risk of DF. These findings provide meaningful information for determining locations or areas where interventions and resources (*e.g*., awareness campaigns, vector monitoring, *etc*.) are needed the most. According to our findings, we recommend that area-specific interventions may be needed, accounting for local socio-ecological contexts of the village. Additionally, this study demonstrated that spatial analytical tools could be applied or integrated in the existing surveillance system to provide evidence in decision making processes (*e.g*., designing and evaluating intervention).

In this study, we also found that the high-risk clusters had a higher ratio of doctor per 1000 people compared to low-risk clusters. This is probably due to more precise reporting. The more available health services, the better the contact with infected patients leading to diagnosis and treatment. This is accordance with findings reported by Watts *et al*. (2020) in the Unites States and Mexico.

This study has several limitations. First, the present analysis was based on passive surveillance data with its potential bias of underreporting as many infected people do not report or present to health facilities if not severely ill. Second, the variation in DF incidence at the village scale may likely occur due to the heterogeneity of socio-ecological factors (*e.g*., disease awareness and behavior, mobility and vector density) (Prasetyowati and Ginanjar, 2017; Ren *et al*., 2017; Chen *et al*., 2019; Harapan *et al*., 2019a; Desjardins *et al*., 2020). However, such data were not available at the village level so that we could not include them the analysis. Despite the limitations, the study has provided important evidence and new approaches in identifying hotspots of DF in Jakarta, which could help improve existing surveillance activities. In the future, population-based epidemiological investigations should acquire a better understanding on DF epidemiology in Jakarta.

The spatial epidemiological approaches used in this study can be utilized and be integrated into the existing surveillance system to monitor and identify areas where intervention is needed at most. Further, understanding the role of the climate on DF distribution could help determine when interventions are needed. For instance, vector control and health promotion campaigns should be prioritised in the identified high-risk locations and certain populations just before the raining season which could be much more efficient and effective.

Conclusions

Our analysis identified a correlation between the DF incidence and local weather (precipitation, humidity, temperature) and regional climate variables, such as the DMI and Niño3.4. confirming that DF seasonality in Jakarta is driven by climatic components. Our study reveals that the DF hotspots remained at particular parts of the city of Jakarta during the period studied. Persistent hotpots are strong indications for the need of enhanced and focal intervention strategies (*e.g*., community-based vector control, campaigns).

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