POLICY BRIEF
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Understanding the Effect of Climate on Health for City Resilience

POLICY LESSONS

- Improve data monitoring and collection for public and private health facilities

  Disease data collection should be standardized, streamlined, and centralized, along with the promotion of eHealth technology use. Not all health centers collect the same data, nor are all high-resolution epidemiological data collected or stored properly and in the same formats (diagnostic, morbidity, or mortality reports) which hinders area comparability and proper analysis.

- Prioritize dengue and leptospirosis hotspots for more targeted prevention programs

  Greater priority should be set for high-dengue and -leptospirosis areas. Areas found to be high-incidence hotspots must be further investigated for housing and land-use, sanitation and sewerage, fumigation, water storage, and flood risk, particularly to reduce its risk of disease transmission.

- Develop co-benefits solutions evidenced by spatio-temporal research and projections on climate- and disaster-related communicable and non-communicable diseases

  Climate extremes like extreme rainfall, drought, typhoons, and flooding are also worth exploring, as this study considered only climate variability, especially if other health outcomes (e.g., cardiovascular and respiratory diseases) will be considered. Developing risk indices (e.g., climate extremes health risk index) and other evidence-based planning guides can enhance co-benefits solutions for both climate and health issues. Such studies can also aid the health components of the National and Local Climate Change Action Plans and Disaster Risk Reduction and Management Plans.

INTRODUCTION

Climate change, together with emerging health risks and population changes, necessitate continuous updates in our current and future health system priorities. In order to do so, an ideal health surveillance system should not only be capable of monitoring diseases accurately, but also be capable of predicting disease burden (Ooi & Gubler, 2009). With this capacity of predicting disease burden, impending outbreaks and general changes in health risks can be estimated to trigger preventive measures and test interventions.

This study aimed to determine the 2010-2017 spatio-temporal distribution and project the 2018 temporal trends of the climate exposures (mean and maximum temperature, relative humidity, and precipitation) and climate-related health outcomes (dengue and leptospirosis) in Quezon City, as well as to determine the relationships among them.

METHODS

This research is an ecological study modeled after the climate-related disease burden baselining and projection method from the United States' Center for Disease Control and Prevention's Building Resilience Against Climate Effects (BRACE) Framework. The method is a scenario-based estimate of the different health impacts associated with variable climate states and trends. Climate data and baseline prevalence are the main data sources for projecting the differential health outcomes associated with climate change.

Baseline disease modeling based on annual data was done using the Generalized Linear Mixed Model to ensure that spatial and temporal interdependencies would not affect modelling. Annual data was used for modelling due to the smallest amount of missing data. Disease forecasting was done using Seasonal Auto-Regressive Integrated Moving Average (SARIMA) and Support Vector Regression (SVR), which were evaluated in a comparative manner using Python. SARIMA is a statistics-based time-series forecasting method, while SVR is a Machine-Learning method. Both were selected for their known effectiveness in time-series modeling, and relatively quick but robust implementation.

For spatial techniques, Spatial Autocorrelation (Global Moran's I), Anselin Local Moran's I (LISA), and Getis-Ord Gi* Hot-spot analysis tests based on fixed distance bands were performed using ArcGIS 10.3 and GeoDa on all exposure and outcome variables using annual barangay-level averages.

This study serves as a proof-of-concept for using spatial epidemiology and Machine Learning methods for disease forecasting at a micro-scale, as well as an illustration of the importance of data robustness. Following the concept of "garbage in, garbage out", having complete and comprehensive climate and disease data for more reliable exposure-outcome associations can more effectively aid decision-makers in developing evidence-based policy for monitoring climate and disease.

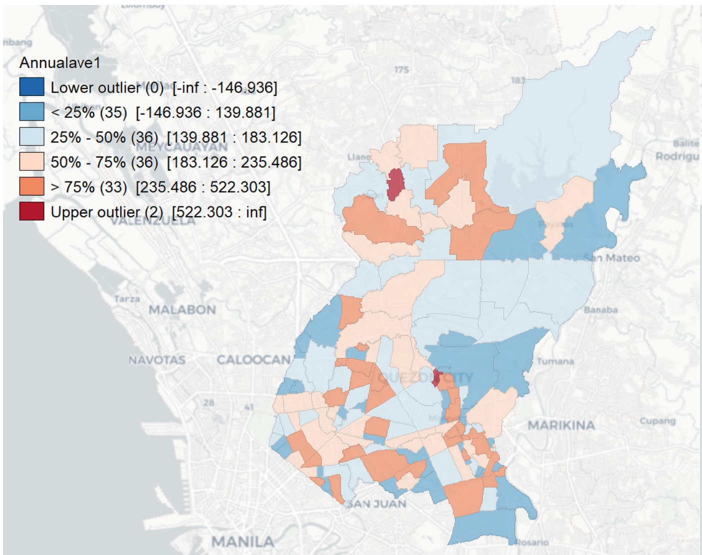

FIGURE 1. ANNUAL AVERAGE DENGUE INCIDENCE

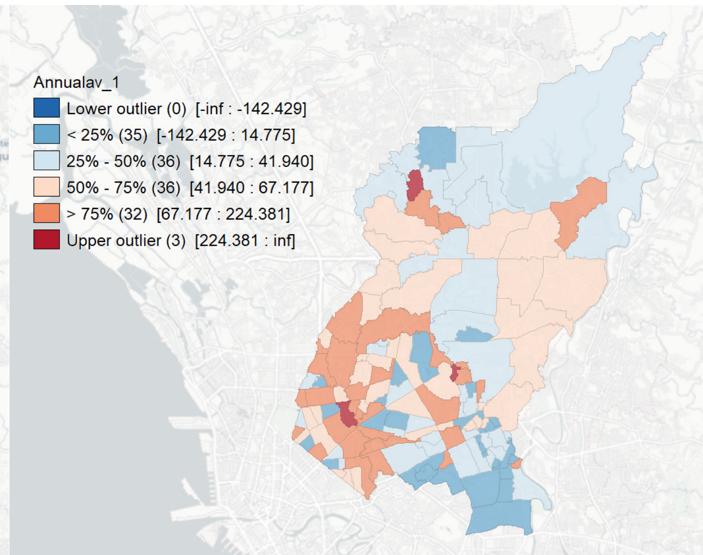

FIGURE 2. ANNUAL AVERAGE LEPTOSPIROSIS INCIDENCE

RESULTS & DISCUSSION

The dengue model showed 2 additional dengue cases per 10,000 people per 1.72% increase in annual relative humidity at the district level. While Malenab et al., (2015) showed no significant association between dengue and relative humidity in some Laguna areas, this study's finding is supported by Costa et al. (as cited in Malenab et al., 2015), and Lorenzo et al. (2011), who found that relative humidity was the only climate variable that exhibited a positive and strong relationship with dengue.

In contrast to the dengue model, all climate indicators yielded significant changes in leptospirosis cumulative incidence at the district level. A 1.03°C and 1.06°C increase in annual mean and maximum temperature will result in 13 and 15 additional leptospirosis cases per 1 million people, respectively. A 1.16% increase in annual relative humidity yielded 4 additional cases per 1 million people, while an 8.33mm increase in annual accumulated rainfall yielded 1 less leptospirosis case per 1 million people. The last finding contrasts with most literature, which show a strong and positive relationship between rain and leptospirosis. Additional station data in other Quezon City barangays should be used to ensure robustness of model and reliability of results, as well as weekly or monthly barangay disease rates. Inclusion of other variables may also explain the inverse relationship (e.g., flooding).

Disease forecasts reflected the peak months consistent with 2010-2017 (July-August). Dengue cases were projected to be significantly less than the previous year, while leptospirosis cases showed only a slight decrease.

Only two barangays significant under the LISA test overlapped across diseases. Barangay West Triangle was a dengue cluster, but a "cold" outlier for leptospirosis, while Barangay South Triangle was a leptospirosis cluster but a "cold" outlier for dengue. This may be good as this shows no double-burden existed in terms of dengue and leptospirosis clustering. However, clusters and "hot" outliers should still be investigated for the high incidence.

Results showed dengue and leptospirosis barangay clusters (high-high) were present based on 2010-2017 data.
Projections show less cases in 2018 for both diseases.

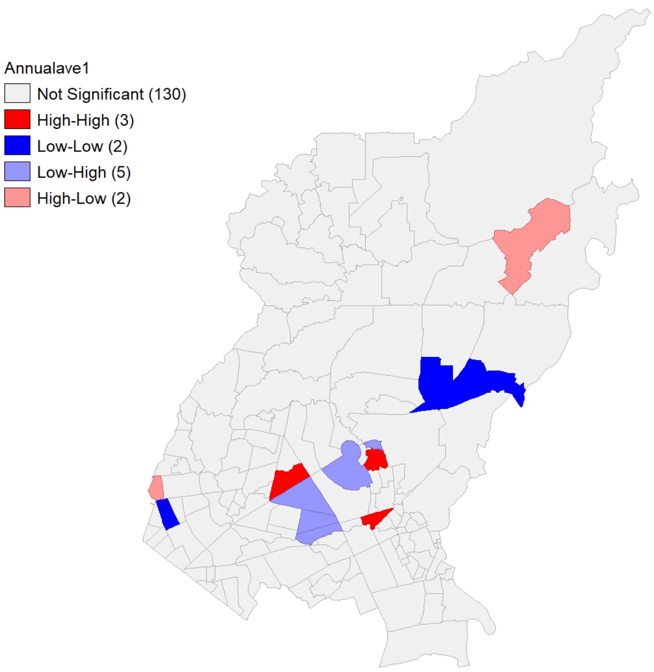

FIGURE 3. DENGUE CLUSTERS (LISA)

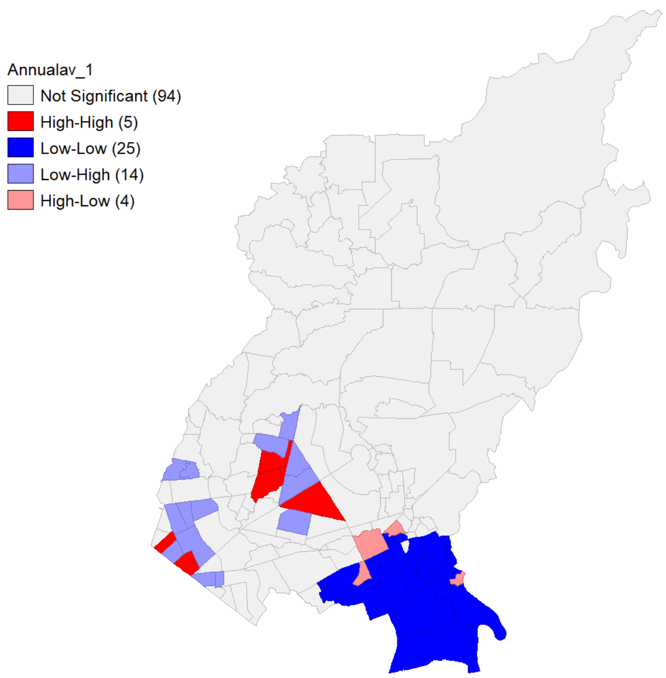

FIGURE 4. LEPTOSPIROSIS CLUSTERS (LISA)

Table 1. Clusters and Outliers for Dengue and Leptospirosis

	DENGUE	LEPTOSPIROSIS	
Hotspot Clusters	UP Village East Kamias West Triangle	Bungad Salvacion South Triangle	Santa Teresita Paltok
"Cold" outliers (low-case areas surrounded by high-case areas)	Central Kamuning Sacred Heart San Vicente South Triangle	Aurora Damar Don Manuel Laging Handa Lourdes Maharlika Pag-ibig sa Nayon	Phil-Am Saint Peter Santo Cristo San Isidro Labrador Sienne West Triangle Veterans Village
"Hot" outliers (high-low)	Payatas San Jose	E. Rodriguez Libis	Quirino 2-A San Martin de Porres

CONCLUSION

Significant relationships between specific climate indicators, and dengue and leptospirosis were established in Quezon City, with leptospirosis significantly clustered across barangays. Given the ease of use and high granularity of the results, modeling and forecasting is recommended for conducting climate and health impact, risk, and resilience studies. This study also emphasizes the need for high-resolution and complete longitudinal historical data for both climate and disease (i.e., 20 years of daily barangay data), as both are important for conducting correlation studies and disease forecasting.

A more accurate picture of Quezon City's climate can also be provided if additional station data is available or other climate indicators are considered. However, climate may be better understood at larger areas, and are not limited to administrative boundaries (i.e., city or district boundaries). Once local downscaled climate models and flood models are available at high resolution, more granular studies on health risks may be conducted. Climate extremes' effect on infectious disease incidence should also be explored as this study was limited to variability at different timescales.

Given Machine Learning technology is essentially a "black box", the algorithm behind the disease forecast using SVR cannot be fully explained. Results must be taken with a grain of salt, and should serve as a likelihood rather than a prediction, as such technological limitations should be noted when considering the disease forecast results for decision-making or planning.

RECOMMENDATIONS

POLICY RECOMMENDATIONS

Improve data monitoring and collection for public and private health facilities

- The Department of Health (DOH) should consider further developing eHealth for the Philippines, in which historical patient data are digitized with appropriate protection and cybersecurity. This can prevent data loss in case of physical storage issues, which hindered this study, and can enable faster, finer-resolution epidemiological research. Digital records can also be more easily recoded to protect personal patient information.
- Disease data collection itself should also be standardized, streamlined, and centralized. Not all health centers collect the same data, nor are all high-resolution epidemiological data are collected or stored and are not in the same formats (diagnostic, morbidity, or mortality reports). Time-series studies require a vast amount of historical data for reliability and long-term disease forecasting, and resilience planning requires high-resolution data for targeted actions. Clearer information flow and communication pathways for data transfer from primary health facilities to centralized storage can also prevent data loss.

ACTION RECOMMENDATIONS

Improved dengue and leptospirosis programs

- Communication campaigns must be regularly done, especially considering recent vaccination concerns. Targeted information dissemination on environmental health beyond rain or flooding and regular cleaning and sanitation may help reduce high incidence areas.
- Greater priority should be set for high-dengue and -leptospirosis areas. Areas found to be high-incidence hotspots must be further investigated for housing and land-use, sanitation and sewerage, fumigation, water storage, and flood risk, particularly to understand the difference with its neighboring areas. The different results and relationships from research may be due to non-climate-related environmental factors unique to each barangay. Changing land-use and poor water storage, which are themselves health risks, may be exacerbated by increasing rainfall or humidity, thereby further increasing the health risks.

RESEARCH RECOMMENDATIONS

Explore other methods

- While the method is largely quantitative in nature, qualitative data should also be used to address knowledge and literature gaps, and to validate the data found with the study populations. Ultimately, the exposure-outcome projections can be a reference point for climate and health management decisions in the short- and long-term.
- Researchers can look into a longitudinal study using daily climate and health data in identified vulnerable areas. Researchers can also consider tracking vector growth and behavior across the years, particularly during high-humidity periods.
- The use of Machine Learning methods should be further explored in conducting disease forecasting and projections.

Develop co-benefits solutions evidenced by spatio-temporal research and projections on climate- and disaster-related communicable and non-communicable diseases

- Other climate-related diseases (e.g., cardiovascular and respiratory diseases) must be explored as such studies are sparse in the Philippines and in developing small island countries in general.
- The relationships between dengue and relative humidity, and leptospirosis and precipitation (not flooding) must be further explored. Minimum temperature might also be worth exploring. Climate extremes like extreme rainfall, drought, typhoons and flooding are also worth exploring, as this study considered only climate variability, especially if other health outcomes (e.g., cardiovascular and respiratory diseases) will be considered.
- Once data is available and as highly accurate as possible, consider the use of downscaled (if possible, 5km^2-grid) climate models in place of station data for studying greater areas. Station data can provide in situ information, but triangulation through in situ and remote data may be best.
- Consider conducting a pilot study on developing best-practice guidelines on dengue and leptospirosis monitoring and prevention at both individual and population levels, particularly in high-incidence hotspots, to aid in evidence-based planning.

CITATIONS

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ORIGINAL RESEARCH

Wong, J., Baladad, A.K., Fowler, K.C., Co, J. (2018). Assessing and Projecting Climate-Related Infectious Diseases in Quezon City. Unpublished Manuscript, Coastal Cities at Risk in the Philippines: Investing in Climate and Resilience Project: Work Package 1.1 Assessing and Projecting Climate-Related Infectious Diseases in Quezon City. Quezon City: Ateneo de Manila University

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