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BAYESIAN SPATIOTEMPORAL MODELS FOR INFECTIOUS DISEASES IN RELATION TO HEALTH INEQUALITY

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This study explores the connection of health inequality to a crucial matter of disease detection that results in the under-reporting of cases. The estimation of the impact of health inequality in disease detection can provide insight to policymakers to develop an optimal allocation of resources and effective mitigation measures. It also helps to continuously evaluate the provision and access to health care resources and services. This study mainly focuses on the estimation of the number of under-reported cases during an infectious disease outbreak in relation to health care resources provided to each geographic area at each point in time.

Chapter 1 establishes the relationship of inequality in health care resources and services to the detection of the fast-spreading infectious disease. Studies in the past have been limited to merely measuring the provision of health care resources and services to ensure equal access to all. However, it is important to determine the impact of any health inequality in relation to the crucial matter of disease detection that can lead to the under-reporting of cases during an infectious disease outbreak. Measures of inequality are introduced in measuring health inequality and the Bayesian framework to estimate the impact of this inequality.

The case studies of Chapters 2 [2] and 3 [1] demonstrate the use of inequality measures in determining the degree of inequality. This degree of inequality is estimated using a Bayesian hierarchical framework that uses two-component modelling that separates the incidence and case detection probability through mixed Poisson modelling, taking into account both spatial and temporal attributes of the data. In addition, Bayesian model averaging is employed in conjunction with the concept of *floating covariates* that is introduced in the study. One of the challenges in

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using this two-component modelling approach is assigning covariates to either of the components of the model. This assignment, or fixed categorisation, introduces a strong prior knowledge into the analysis and requires additional knowledge or expertise to be done precisely. Alternatively, the concept of floating covariates addresses the need for fixed categorisation and dependence on expert knowledge for it. Furthermore, Bayesian model averaging allows flexibility in the models to determine floating covariates' chances to contribute to the parameter estimates for the component models. The inclusion of all candidate models in the model space improves the accuracy of estimation. An application to a commonly experienced infectious disease, influenza, is demonstrated using this Bayesian hierarchical framework in Chapter 3. This framework is improved by introducing robust logistic regression in the case detection probability component of the model and applied to COVID-19 in Chapter 4. This study is driven by the recent pandemic, wherein resource allocation is crucial in successful and timely surveillance, mitigation and planning.

Based on the implementation of the two case studies, the last investigation in Chapter 5 is the computational performance of implementing complex Bayesian spatiotemporal infectious disease models. Infectious disease modelling usually incorporates spatial and temporal attributes to capture the dynamic nature of the disease. As a result, infectious disease models can become computationally complex and burdensome. An approach is explored to speed-up the run-time of modelling infectious diseases in the software Just Another Gibbs Sampler (`JAGS`).

To conclude, the proposed Bayesian approach helps to determine areas with potentially under-served health care resources and under-reported infectious disease cases. The inclusion of both the spatial and temporal attributes provides a practical, flexible and timely modelling. At the same time, it does not require costly and time-consuming surveying and preparations by mainly relying on data at hand.

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