A Marginalized Zero-Inflated Spatially Varying Coefficient Model for Disease Modeling

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SUMMARY

Spatial information is increasingly becoming an important public health tool for systematic disease surveillance. Their significance in public health emergence response extends beyond their use for disease data collection and storage, but their configuration plays a crucial role in spatial disease mapping. In this study, we present a challenging feature of excess zeros present in a spatial surveillance system when monitoring sporadic epidemic diseases loke cholera. Zero-inflated Poisson (ZIP) models are often used to accommodate the presence of excess zeros. We previously developed a zero-inflated Poisson spatially varying coefficient (ZIPSVC) model to account for the varying exposure effects for cholera. However, there are inferential and interpretation challenges relating to modeling the exposure effects. The latent class interpretation that corresponds to the susceptible sub-population is often wrongly inferred to the sampled population. In this study, we propose a marginalized ZIPSVC (MZIPSVC) model to address the following: (1) to estimate the overall marginal log-incidence density ratio of the sampled population, (2) to determine the spatially varying log-incidence density ratios of the sampled population, and (3) to estimate the spatially varying exposure effects on the sampled population. We tested the MZIPSVC model via a simulation study and compared it with the ZIPSVC model. We found that the MZIPSVC model consistently recovers the true parameters under the simulations. We illustrate the method by making inferences on the spatial distribution of district-level cholera incidences in Ghana. Unlike the ZIPSVC model, the MZIPSVC model allows straightforward inference of the exposure effects on the sampled population in a similar sense expected from Poisson regression. We conclude that (1) the MZIPSVC and MZIPSVC models have different exposure effects estimates as are their interpretations, and (2) the choice of either MZIPSVC or ZIPSVC should be guided by how one intends to infer the estimated exposure parameters.
