

Descriptive GIS Analysis of Autism Spectrum Disorders in Kelantan, Malaysia: Severity Patterns and Service-Related Clusters

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Autism spectrum disorder (ASD) in Kelantan, Malaysia remains poorly characterized geographically, with stark diagnostic disparities by severity. Kelantan is predominantly rural, and no prior study has quantified the state's ASD spatial distribution. The present GIS-based analysis mapped 103 ASD diagnoses (13 severe, 30 high-functioning, 60 mild autism) by geocoding their locations. Mean centers of all cases lay near Kota Bharu, but dispersion differed markedly. Severe ASD cases formed a tight urban cluster (standard deviational ellipse area 250.52 m²) while mild autism cases were broadly dispersed (SDE 526.25 m²). LISA (Local Moran's I)

revealed statistically significant high-high clusters of mild and high-functioning ASD in Kota Bharu and nearby districts, whereas severe ASD showed no contiguous hotspots. These patterns highlight urban-rural diagnostic disparities: milder ASD is over-represented in well-served cities, whereas severe ASD was relatively uniformly reported statewide. This first GIS-based spatial epidemiology of ASD in Kelantan provides novel insight into under-detection of mild autism cases in rural areas. These findings imply that screening and support services should be expanded beyond metropolitan areas to bridge Kelantan's urban-rural ASD

care gap, guiding more equitable resource allocation. This spatial analysis offers a data-driven foundation for planning ASD surveillance, outreach, and interventions statewide, informing equitable policy.

Keywords: Autism spectrum disorder; Kelantan; local indicators of spatial association (LISA); spatial distribution; standard deviational ellipse (SDE)

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by impairments in social communication and restrictive, repetitive behaviors. Its prevalence has risen dramatically worldwide in recent decades (Anaclerio et al. 2024; Tartaglione et al. 2024). In Malaysia, for example, national estimates indicate an increasing ASD burden, yet regional rates vary widely. The northeastern state of Kelantan shows one of the lowest reported ASD prevalences in the country (Shair et al. 2024), raising concerns that many cases may go unrecognized or undiagnosed. Descriptive statistics alone (e.g. case counts, age/sex distributions) provide important baseline information, but they cannot reveal whether and where autism cases cluster in space. Spatial epidemiology adds a critical “where” dimension: it can detect geographic clustering of cases, highlight potential environmental or service-related determinants, and guide resource allocation to underserved communities (Hu et al. 2025; McGrath et al. 2020; Roman-Urrestarazu et al. 2022). In short, GIS-based mapping can uncover patterns that traditional epidemiology misses.

To address this gap, we conducted the first GIS study of ASD in Kelantan (Ijon et al. 2026). Our objectives were to map the locations of confirmed ASD cases (mild, moderate, and severe) and apply spatial statistics to quantify their patterns. Specifically, we used mean center analysis to assess the geographic central tendency of cases, standard deviational ellipses to

measure dispersion and orientation, and Local Indicators of Spatial Association (LISA) to detect local clusters and outliers. Through these methods, we ask: Do ASD cases concentrate in particular districts or urban centers? Do mild versus severe cases show different spatial footprints? By answering these questions, we aim to generate new insights into the geography of autism in Malaysia, informing targeted outreach and service planning for this vulnerable population.

Literature Review

Autism case mapping is relatively rare globally. Most ASD research focuses on individual risk factors (genetic and environmental) and prevalence, but seldom on spatial distribution. Nevertheless, prior studies in other countries illustrate the value of GIS in autism research. For example, a large-scale study in England found that autism incidence was non-uniform across regions: statistically significant “hotspots” of high ASD incidence appeared in urban areas like London and Manchester, while lower rates occurred in more rural districts (McGrath et al. 2020; Roman-Urrestarazu et al. 2022). Similarly, spatial analysis of New York State school districts revealed significant clustering of high ASD rates in New York City and Albany (McGrath et al. 2020; Roman-Urrestarazu et al. 2022). These findings suggest that geography and sociodemographic factors (e.g. service availability, language barriers) influence where autism is diagnosed. Importantly, spatial statistics such as Moran’s I and LISA have proven effective in identifying such hotspots and coldspots. In general, spatial epidemiology approaches can identify clustering patterns of disease, assess environmental or sociodemographic exposure risks, and optimize allocation of resources (Hu et al. 2025). In this context, analyzing ASD spatial patterns can reveal whether undiagnosed cases are geographically clustered, for example, if remote rural communities are under-served compared