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# Spatial Dimension of COVID-19. An Exploratory Approach to Investigate Spatiotemporal Profiles of Epidemiological Trajectories in Japan

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The COVID-19 pandemic constituted an exogenous shock with multidimensional effects on geographical systems. The heterogeneity of economic, social, political contexts, and phases of the disease's spread extends to the heterogeneity of epidemiological data. Studies dealing with the socioeconomic and spatial factors of disease diffusion do not provide clear and unambiguous conclusions. Furthermore, with the overrepresentation of the United States of America in case studies, a confirmatory bias is created in the hypotheses and conclusions of studies examining other comparable countries (OECD) (Brodeur et al., 2021; Ladmiral, 2021). However, it can be questioned whether different systems of social protection and public health similarly expose or protect different segments of populations. Japan, along with Sweden, is the only OECD country that did not impose strict coercive measures (lockdown) in controlling the COVID-19 epidemic. Additionally, the Japanese political system, characterized by strong decentralization of legislative and executive powers, has led to significant variations in the definition and implementation of control measures across the country's 47 prefectures. The case of Japan is interesting in many ways but remains insufficiently studied.

Factors influencing the spread of COVID-19 in Japan have so far been analysed using epidemiological data aggregated at the administrative level of prefectures (都道府県 – Todofuken) (Yoshikawa and Kawachi, 2021; Kondo, 2021). However, in Japan or elsewhere, such level of aggregation does not allow for a precise study of the disease's propagation process. The significant loss of information due to aggregation at this scale, coupled with the small sample size resulting from it, reduces the power of analysis methods and the reliability of the results. Moreover, the treatment of the spatial dimension in relation to the COVID-19 epidemic is primarily descriptive in the academic literature. Spatial analysis often focuses on the identification of hot and cold spots (Yabe et al., 2022), clustering of contaminated areas (Andrews et al., 2021), or the identification of spatial autocorrelations in affected/spared zones (Elarde et al., 2021). Hence, the main objective of this research is to identify epidemic trajectories during different "waves" of COVID-19 and construct a typology of socio-spatial profiles of epidemiological curves. The results shall contribute to a better understanding of the functional relationships between the municipalities in Japan during the 2020-

2021 health crisis. The originality of this project lies not only in the possession of precise and costly data or the study of an underexplored case but also in the development of new analysis protocols through the hybridization of spatial analysis and epidemiological methods. Indeed, this research project benefits from the epidemiological dataset constructed by the Pandemics and Societies group<sup>1</sup> thanks to a funding provided by Kyoto University (GAP Fund 2020/09-2022/01). This dataset, which has yet to be published, collects epidemiological data at the level of over 1700 municipalities (市区町村 - Shikuchoson) in Japan, as well as from approximately 450 health insurance and surveillance centers (保健所 - Hokensho) throughout the entire period from 2020/01 to 2021/11. The funding has also facilitated the acquisition of a mobile phone dataset that depicts mobility within the 1700 municipalities in 2019, 2020, and 2021 on a weekly basis.

In order to identify epidemic trajectories and define a typology of socio-spatial profiles of epidemiological curves, several protocols are being developed, including the conception of a pair-wise matrix of weekly flows (146 weeks) for the 1700 municipalities, the use of statistical scanning windows and finally the clustering of observation based on spatiotemporal trajectories. In spatial epidemiology, statistical scanning windows (e.g Takahashi et al., 2008) allow for the detection of anomalies in the distribution of variables associated with nodes based on a graph of connected regions (based on border contiguity). The search for associations is conducted in a circular manner (connected nodes within a varying radius) or linearly (projection of node-to-node on the graph). These methods are suitable for detecting spatial clusters of count data (deviations from an expected distribution, such as Poisson). Our team is currently exploring an approach that involves substituting the physical space with a relational space defined by the bidirectional mobilities available in the pair-wise matrix. In order to do so, the municipalities are transformed into non-overlapping circles (cartogram, Dorling, 1996) before being rearranged during a pair-repulsion step. The connected nodes on the graph are then defined based on the obtained rearrangement, and these connections are used to run the statistical scanning windows. The detection of clusters of incidence/prevalence obtained on the physical and on the relational space are compared and analysed for different epidemic waves. A second clustering is then applied for all weeks defining a particular epidemic wave on the categorical states identified through the statistical scanning windows (primary cluster of incidence/prevalence, secondary cluster and no cluster) to obtain spatiotemporal profiles of epidemiological trajectories. This exploratory approach allows deriving spatiotemporal profiles of epidemiological trajectories, shedding light on the intricate dynamics of the COVID-19 pandemic in Japan. Methodological advances and thematic results will be presented at the conference, focusing on specific subsets, regions and profiles of epidemiological trajectories.

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