% Infectious disease, such as COVID-19 Until the preparation of this article, the outbreak of Coronavirus disease 2019 (COVID-19, or nCoV-2019, caused by SARS-CoV-2) is still an ongoing issue (REF-WHO). The pathology of the COVID-19 remained an open issue, and the development of the vaccines and medicines for treating COVID-19 are still under processing. To the current understanding, COVID-19 is more infectious than the 2003 Severe Acute Respiratory Syndrome (caused by SARS-CoV-1), the main transmission method is through respiratory droplets, and the infected patients would experience a (about) 14 days latent period before starting to have symptoms and become infectious (REFs). The asymptomatic latent period of COVID-19 and its highly contagious disease properties had made COVID-19 even more difficult to be control and prevent.

The outbreak of COVID-19 started in December 2019 at Wuhan City, Hubei Province of China, which started to spread worldwide in January of 2020, lead to the declaration of a Public Health Emergency of International Concern (PHEIC) by WHO (REF-who-report-10). Until the declaration of PHEIC, 7818 cases were confirmed, in which 82 were out of China cases (REF-who-report-10). In February, the COVID-19 started to spread internationally, especially to the East and South East Asia, and some European countries who had direct and intensive population flow with China. The countries in this first wave of outbreak included Thailand, Singapore, Japan, South Korea, France, Germany and United Kingdom (REF). In March, the epicenter of COVID-19 moved to Europe beginning with the outbreak in Italy (REF), which were the second wave of outbreak and international pandemic. The second wave countries were believed to be influenced by the countries in the first wave outbreak, which formed a spatial disease diffusion chain. The second wave outbreak triggered the lock-down in most of those countries (REF). The purpose of the country or city level lock-down is to reduce the chances of imported cases, and to restrict the human movement to stop the disease spreading spatially within the country.

% spatial network as a tool to understand the disease diffusion process Spatial network is a convenient tool to conceptualize the networked interactions between places. Previous studies studied the flows of people within countries (REFs) and internationally (REFs) to uncover the underlying spatial structure of the network and its effects on the interactions, e.g. to quantify the vulnerability in resources flow (Ducruet, Lee, and Ng 2010), to clarify the roles and positions of cities in a global business network (Alderson and Beckfield

2004), and to identify the distribution of population concentration (Jiang 2009, @chin-GeographicallyModifiedPageRank2015b). Spatial networks were also used to understand the disease diffusion, which were usually a results of human flows. REF (TaPiTaS, a island wide country scale). REF (simulation in USA, a large country + simulation). REF (Balcan, GLEAMviz, global and local diffusion simulation).

% super-spreaders, which is a popular social network analysis topic, could provide some insights on revealing the places that were influential in the disease diffusion process and on uncovering the vulnerable places. The identification of super-spreaders is a popular topic in social network studies (REF Pastor2001 - latest).

% vulnerability, receiver

% the focuses of this study The aim of this study is to identify the super-spreader and super-receiver in a commuting network. A spatial super-spreader is a location where a lot of people are moving from, and those people are moving to different places; a spatial super-receiver is the destination of a large number of commuters, who come from different places. In other words, there is two keys to identify super-spreader and super-receiver, which is local density and neighborhood diversity (REF). The local densities of a location are the number of people leaving from or reaching to the location. The neighborhood diversities contains two type of diversity, one of which is the diversity of zones, i.e. are the people come from different parts of the country; another is the diversity of coreness, i.e. are the people come from different types of the country in terms of core or peripheral areas. In this study, we present the analysis of Singapore public transport flow network, and identify the spatial super-spreaders and super-receivers using the spreader and receiver indexes, which were calculated based on the local densities and neighborhood diversities measurements. The population flow pattern may be different for weekday and weekend. Thus, the flow data were separated into two parts, weekday and weekend, to show the differences of super-spreaders and super receivers during weekdays and weekends.

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