Vulnerability and the Wanderers: Suburban Syndrome in the Chi-Chi Earthquake

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From 1996 to 2015, earthquakes resulted in over 750,000 deaths, comprising 55.6% of all natural disaster fatalities according to an UNISDR report in 2016. While earthquake intensity and population exposure are important determinants in the seismic risk, they cannot solely explain the earthquake fatality distribution. By merging seismologic, demographic, and socioeconomic datasets to estimate the social and physical determinants of the Chi-Chi earthquake, our previous study proved that seismic hazard (i.e., ground motion and fault crossing), exposure of population, building fragility (i.e., susceptibility to earthquake damage), and social vulnerability (i.e., high proportions of children, elderly, women, lower income family, and income inequality) are critical determinants for the earthquake fatalities (Lin et al. 2015). Moreover, intensive fatality is commonly found in association with collapsed condominiums (also termed as housing complex or building complex, meaning a large building or group of buildings designed for residential uses), not only in the Chi-Chi earthquake, but also in the 2016 Meinong earthquake, and the 2018 Hualien earthquake. By integrating the collapsed condominium data in the Chi-Chi earthquake, Lin et al. (2017) further proved that collapsed condominium is an extraordinary factor contributing to the deterioration of the fatalities. More intriguingly, social vulnerability factors associated with the collapsed condominium is distinct from the general factors in the seismic fatality. Middle aged population, middle level family income, and higher income inequality characterize a higher risk in the collapsed condominium.

Based on the previous studies, we further proposed a socio-spatial relationship behind the disaster risk controlling the social vulnerability factors. Among the earthquakes in Taiwan (1999, 2016, 2018), Wenchuan of China (2008), Central Chile (2010), and Gorkha of Nepal (2015), higher mortality was observed clustering in small-to-medium-sized cities and suburbs of the metropolitan areas, for which we termed ‘the suburban syndrome’. The suburban and small-to-medium-sized cities generally feature limited financial resources, inadequate governance capacity, higher proportions of migrant and lower income families and informal settlements that collectively shape their exceptional vulnerability and disaster risk, and yet the risk is underestimated. We argue that among these factors, migratory behavior is the most dynamic, and its effect is largely underestimated due to a lack of official data. To fill the research gap, we used a radiation model to estimate the migration pattern and its effect on the seismic risk in the case of Chi-Chi earthquake (Chen et al. 2024). By applying multidisciplinary data in the 4,052 neighborhoods (spectral acceleration at 0.3 second equal to or bigger than 0.14g, suggesting no damage below this magnitude), three nested multivariate Poisson Regression models were established. The research result proves that, in addition to the traditional hazard, exposure, and vulnerability factors, migrating behavior is a critical factor deteriorating earthquake fatalities in the suburban syndrome especially for the indigenous and lower-income migrants. The cause and effect are multidimensional.

By 2030, small-to-medium-sized cities with less than one million population will register 54% of the world's urban population according to the UN statistics. Challenges such as financial constraints, governance deficiencies, and inadequate regulation of construction and building codes, particularly amid rapid urban expansion, will escalate seismic risks. Therefore, there is a compelling need to call for enhanced social protection and implementation of regulatory frameworks in living and housing infrastructures for migrating workers, lower-income groups, and marginalized populations to reduce their vulnerability in the disaster risk.

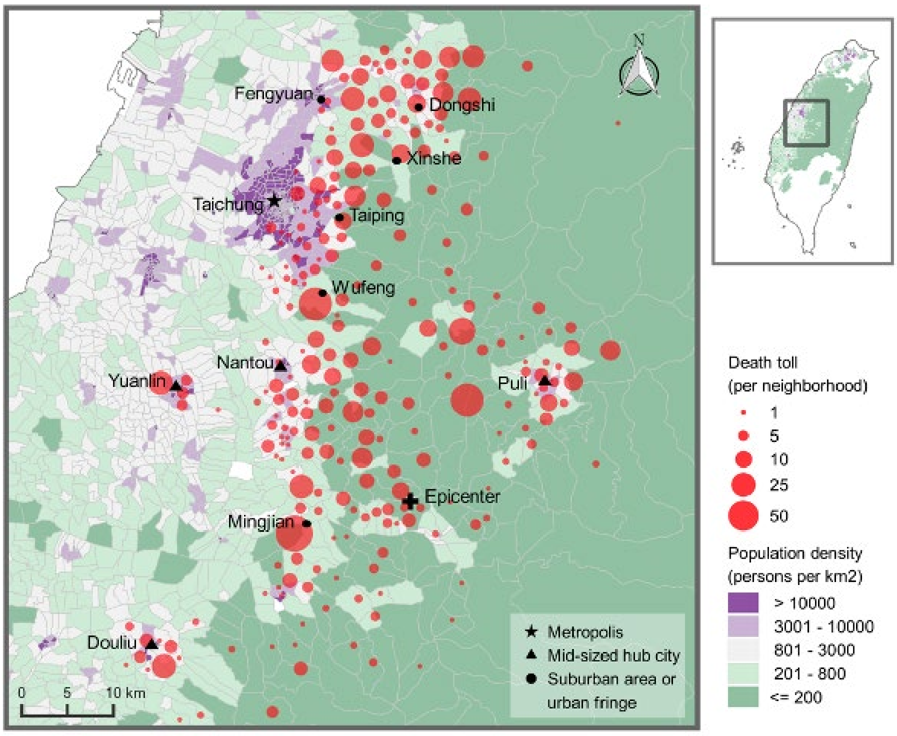

Figure 1. Suburban syndrome in seismic fatalities of the Chi-Chi earthquake. Spatial distributions of fatalities and population density indicate that the neighborhoods in medium-sized hub cities, suburban areas, and urban fringes suffered the most fatalities during the Chi-Chi earthquake. Source: Chen et al., 2024.

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