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Resilience of aging populations after devastating earthquake event and its determinants – A case study of the Chi-Chi earthquake in Taiwan

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1.Background
Major portions of urban areas in Asia are highly exposed and vulnerable to devastating earthquakes. Many studies identify ways to reduce earthquake risk by concentrating more on building resilience for the particularly vulnerable populations. By 2020, as the United Nations' warning, many Asian countries would become 'super-aged societies', such as Taiwan. However, local authorities rarely use resilience approach to frame earthquake disaster risk management and land use strategies. The empirically-based research about the resilience of aging populations has also received relatively little attention. Thus, a challenge arisen for decision-makers is how to enhance resilience of aging populations within the context of risk reduction. This study aims to improve the understanding of the resilience of aging populations and its changes over time in the aftermath of a destructive earthquake at the local level. A novel methodology is proposed to assess the resilience of aging populations and to characterize their changes of spatial distribution patterns, as well as to examine their determinants.

2.Methods and data
An indicator-based assessment framework is constructed with the goal of identifying composite indicators (including before, during and after a disaster) that could serve as proxies for attributes of the resilience of aging populations. Using the recovery process of the Chi-Chi earthquake struck central Taiwan in 1999 as a case study, we applied a method combined a geographical information system (GIS)-based spatial statistics technique and cluster analysis to test the extent of which the resilience of aging populations is spatially autocorrelated throughout the central Taiwan, and to explain why clustering of resilient areas occurs in specific locations. Furthermore, to scrutinize the affecting factors of resilience, we develop an aging population resilience model (APRM) based on existing resilience theory. Using the APRM, we applied a multivariate regression analysis to identify and examine how various factors connect to the resilience of aging populations. To illustrate the proposed methodology, the study collected data on the resilience attributes, the disaster impacts and damages due to the Chi-Chi earthquake. The data were offered by the National Science and Technology Center for Disaster Reduction, Taiwan, as well as collected from the National Land Use Investigation, official census statistics and questionnaire surveys.

3.Results
Integrating cluster analysis with GIS-based spatial statistical analysis, the resilience of aging populations were divided into five clusters of distribution patterns over the 10 years after the Chi-Chi earthquake. It shows that both population and elderly distributions were highly heterogeneous and spatial correlated across the study areas. We also demonstrated the 'hot spots' areas of the highly concentrated aging population across central Taiwan. Results of regression analysis disclosed the major factors that caused low resilience and changes of aging population distributions over time. These factors included the levels of seismic damage, infrastructure investments, as well as the land-use and socioeconomic attributes associated with the disaster areas. Finally, our findings provide stakeholders and policy-makers with better adaptive options to design and synthesize appropriate patchworks of planning measures for different types of resilience areas to reduce earthquake disaster risk.