

Study of post-disaster indirect death - by the case of the Great East Japan Earthquake and Tsunami-

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1. BACKGROUND

The first target agreed in Sendai Framework is to substantially reduce global disaster mortality by 2030, while it is advocated to establish a mechanism and database of mortality. The common classification of disaster mortality consists of direct and indirect deaths; however, the mechanism of indirect death is unclear due to limited surveillance periods and inappropriate definitions and criteria (Pines 2007). Counting indirect death is still overlooked completely in some studies (McKinney et al. 2011), and data of indirect losses are not generally obtainable (Wirtz 2014). To improve the utility of the Sendai Framework, it is necessary to address data collection and monitoring processes by identification and collective consideration (Green 2019).

In 2017 Centers for Disease Control and Prevention (CDC) defined it as an event that occurs when unsafe or unhealthy conditions are present during any phase of a disaster (i.e., pre-event or preparing for the disaster, during the disaster event, or post-event during cleanup after a disaster) and contributed to a death. Although it is named disaster-related death (SaiGaiKanRenShi in Japanese), it is officially defined as post-disaster perish due to injury aggravation from the hazards or illness caused by physical burden during evacuation, recognized by the Law of Condolence Money (Act No. 82 of 1973) results from disaster, which is also applied to recognize indirect deaths that occur over the long term.

The Great East Japan Earthquake (GEJE) in 2011 triggered the tsunami and Fukushima nuclear accident, with which it caused 19,759 direct deaths and 3,784 indirect deaths. Official indirect death is reported by Reconstruction Agency based on analysis of death certification, screening material from municipal authorities and hearing with government officers. Despite this surveillance system receiving criticism inclusive of biased screening process, it in the first place all over the world monitors the indirect death of natural disasters since 1995 and provides with authoritative statistics which reflect the long-term effects of natural disaster.

2. OBJECTIVES

In this study the research objective is to clarify the mechanism of post-disaster indirect death, by assessing Japan's surveillance system and investigating the socioeconomic determinants of indirect death. The hypothesis of this context is that post-disaster indirect mortality and the importance of its social determinants have been underestimated among prefectures, cities, towns, and villages. Thus, better accountability for indirect deaths is

required so we can monitor the cause and impact of disasters more comprehensively. Using the case of the Great East Japan Earthquake and Tsunami, this study inspects Japan's indirect post-disaster death surveillance system and clarify a mechanism to optimize its certification, which plays a crucial role in providing reliable statistics for recovery evaluation.

3. METHODOLOGY

Firstly, to assess Japan's surveillance system, a wide range of literature is reviewed to compare its definitions, then an excess mortality model was built to estimate the death toll of indirect mortality. Secondly, to investigate the socioeconomic determinants of indirect death, regression analysis was developed to investigate the correlations between indirect mortality and its social determinants.

3.1 Examining the surveillance system

In order to create a control group for 2011–2017, data between 2000–2010 and 2018–2019 were used to train a Gaussian process model Equation (1) to estimate a set of plausible coefficients for calculating excess deaths in Equation (2). Then, Equation (3) was used to collect indirect deaths from different cohorts.

$$N_{m,y} = \alpha_m \cdot Y_{2000\sim 2010\&2018\sim 2019} + \beta_m + \epsilon, \epsilon \sim N(0, \sigma^2) \quad (1)$$

Regressing the Gaussian process with a Bayesian approach functions well on small time-series data sets capable of providing uncertainty measurements on the predictions for each municipality employed as the smallest unit. In the generalized linear model Equation (1), N denotes the observed number of all-cause deaths in the municipality of m and the year of y . The constant α is a linear slope for the municipality of m across years. β refers to a separate intercept as fixed effects in each municipality of m from the difference in population structure, migration rate and other socioeconomic factors. Y is an independent variable of year ranging from the years 2000–2010 and 2018–2019, and ϵ is the Gaussian noise following the normal distribution fluctuating around zero.

$$E(N_{m,y}) = \hat{\alpha}_m \cdot Y_{2011\sim 2017} + \hat{\beta}_m \quad (2)$$

$$I = \sum_j^C \{ \sum_i^{2011\sim 2017} [N_{j,i} - E(N_{j,i})] - D_j \} \quad (3)$$

All α and β estimated from Equation (1) are used in Equation (2) to calculate the expected number of counterfactual deaths in municipality m in year Y (2011–2017). Equation (3) was developed to predict the number of indirect deaths I by summing municipality j in cohort C after adding up the excess numbers of year i 2011–2017. D

refers to number of direct deaths of municipality j and it is assumed in this study that by subtracting excess death by direct death indirect death is acquired. By referring to a specific cohort, we can obtain the predicted number of indirect deaths by resetting C (e.g., prefectures, municipality, etc.).

3.2 The socioeconomic determinants

Ordinary Least Square (OLS) and robust regression methods which can be robust to assumption violation are applied to equation (4). Y is the indirect mortality, α is the intercept, δ is the standard error, X is the independent variables of different aspects, β is the coefficients and i denotes to each municipality.

$$Y_{\text{Indirect death}} = \alpha + \sum_{i=1} (\beta_i \cdot X_i) + \delta \quad (4)$$

Data process and calculation is practiced in Posit Cloud by R language. Moreover, details of the death from Case Studies of Disaster-Related Indirect Deaths from the Cabinet Office are input into KH coder to operate text mining analysis.

4. RESULT

4.1 Estimation

The impact of the mega disaster GEJE on the population was more profound than that reported by official statistics or news. A total of 4657 indirect deaths were estimated in Fukushima, Iwate, and Miyagi prefectures, which is much higher than the reported number 3784, demonstrating a possible underestimation of indirect deaths in the case of the GEJE.

In Miyagi, it was estimated that 12,295 excess deaths occurred between January and December 2017, with 1734 possible indirect deaths. Subtracting the 925 reported direct deaths, we can confirm that 809 cases were ignored. In Iwate, 6457 excess deaths were captured by the model, which predicted 1350 indirect deaths compared to the 467 reported indirect deaths. Consequently, 883 cases were missed by the surveillance system. In Fukushima, the predicted 1573 indirect deaths fell below the reported 2229 indirect deaths, which means that 656 cases were overreported.

4.2 Correlation

We begin with the classic regression model, namely OLS and found distance to epicenter, nuclear impact, single household rate, marriage rate, average income, employment rate and female life expectancy are significantly interconnected with indirect mortality. The result demonstrates that the closer a municipality is to the epicenter, the lower indirect mortality. A municipality relatively close to the epicenter tends to be located on the coast, since the variable Coastal region has no significance, it turns out that the nuclear accident ($***p < 0.001$) and earthquake can be the determinants for indirect mortality rather than tsunami. Single household rate is found to have

a significantly relation with indirect mortality, which can be interpreted that in a municipality every 1% rise in one-person household there will be 0.58% increase in the indirect mortality. Otherwise, 1% higher marriage rate means 1.39% higher indirect mortality ($*p < 0.05$). Regarding economic indicators, income has slightly positive impact on indirect mortality as opposed to employment rate. Moreover, every one year increased in average female life expectancy can relate to 4.61% less indirect mortality.

8. CONCLUSIONS

The numbers of indirect death are estimated by the epidemiological model, however, these numbers per se can be underestimated or overestimated due to survivor bias as well as the accuracy of the officially reported number due to screening bias. Aiming to improve the precision of the model used in this study, determinants focused on socioeconomic aspects were analyzed to help with providing more appropriate variables for developing this model.

Among all the determinants verified in this context, whether one is living alone is related with indirect mortality with a high significance and higher one-person household rate correlates with higher indirect death. This result is a warning alert for Japan's society as it has been quickly changing into a more individualized society than how it was years before. On the other hand, it was found that fifty more direct deaths happening averagely can induce one indirect death under the circumstance not considering Sendai city which is a municipality that is way more developed than the others.

Moreover, economic hardship, education level and health status are commonly tested, however the targeted area is not faced with severe resource inequality inclusive of wealth thus average income doesn't appear to be a strong determinant. On the other hand, it is demonstrated that gender has a relation with the indirect mortality because solely female life expectancy can negatively interconnect with indirect mortality instead of male life expectancy.

REFERENCES:

- Green, Helen K., et al. "Challenges with disaster mortality data and measuring progress towards the implementation of the Sendai framework." *International Journal of Disaster Risk Science* 10.4 (2019): 449-461.
- McKinney, Nathan, Chris Houser, and Klaus Meyer-Arendt. "Direct and indirect mortality in Florida during the 2004 hurricane season." *International journal of biometeorology* 55.4 (2011): 533-546.
- Uscher-Pines, Lori. "" But for the Hurricane": Measuring Natural Disaster Mortality over the Long Term." *Prehospital and disaster medicine* 22.2 (2007): 149.
- Wirtz, A., Kron, W., Löw, P. et al. The need for data: natural disasters and the challenges of database management. *Nat Hazards* 70, 135–157 (2014).