Travel distance to hospital is associated with self-harm hospital presentation but not suicide: a small-area study from New Taipei City, Taiwan

Electronic Supplementary Material 1 (ESM 1)

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Contents

1. Methods

Data source

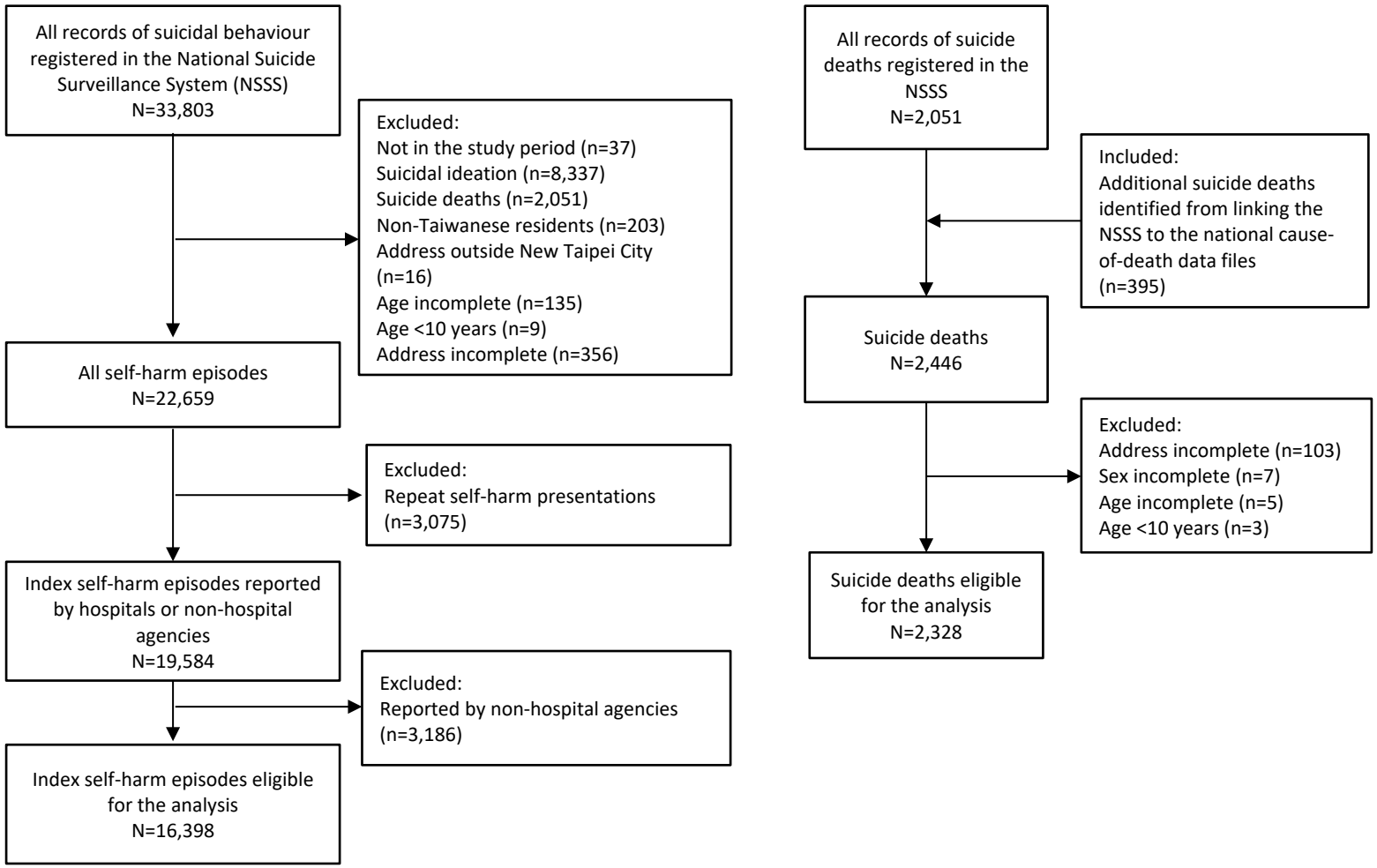
Geocoded data for self-harm and suicide in New Taipei City (2012-2016) were primarily extracted from Taiwan's National Suicide Surveillance System (NSSS). In 2012-2016, there were 33,803 records of suicidal behaviours (suicidal ideation, self-harm, and suicide deaths) amongst residents who lived in New Taipei City being reported to the NSSS. To identify self-harm presentations for our analysis, we excluded records that were outside the study period (n=37), suicidal ideation (n=8,337), suicide deaths (n=2,051), self-harm by non-Taiwanese residents (n=203), self-harm by individuals with a residence address outside New Taipei City (n=16), and self-harm episodes with missing information on age (n=135), an age <10 years (n=9), or incomplete information on residential addresses (n=356) (Appendix Figure 1). We extracted the first self-harm episode of the same individuals during the study period (i.e., index self-harm episode) and excluded repeat self-harm presentations (n=3,075). A total of 19,584 index self-harm episodes were identified; 83% of them were reported by hospitals (n=16,398), and 17% (n=3,186) were reported by other agencies, mainly the police and firefighters. For self-harm, we included only self-harm episodes presented to and reported by hospitals as we focused on self-harm hospital presentations in the study.

For suicide, we included all suicides reported by hospitals or non-hospital agencies to the NSSS. We first identified 2,051 suicide deaths reported to the NSSS that had an address within New Taipei City. We then identified an additional 395 suicide deaths from the national cause-of-death data files (2012-2016) that had a residential address within New Taipei City (n=3,305). These additional suicide deaths were not captured

in the NSSS as they were apparent deaths when being found and were not sent to hospitals. The police did not report these deaths to the NSSS as the cause of death was yet to be certified later by legal personnel (prosecutors). This resulted in a total of 2,446 suicides. After excluding suicides with missing or incomplete information on residential addresses (n=103), sex (n=7), or age (n=5) and those aged <10 years (n=3), a total of 2,328 eligible suicides (70.4% of 3,305) were included in the analysis (Appendix Figure 1).

Information was collected on demographic characteristics, the date of self-harm or suicide, and residential address for both self-harm episodes and suicides. Based on the residential address, each index self-harm episode and suicide was assigned to one of the 1,032 neighbourhoods (the smallest administrative unit with detailed demographic data in Taiwan) in New Taipei City. The neighbourhood population data were extracted from the New Taipei City government's open data website (Department of Civil Affairs, 2018). The median population aged 10 years or above in the neighbourhoods was 3,426 (range 157-14,289).

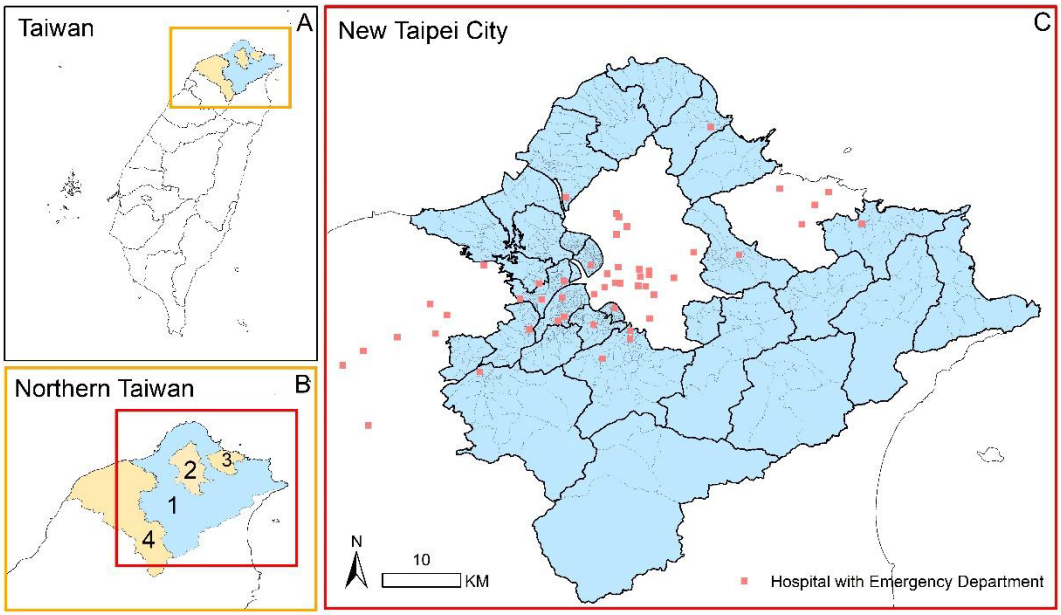
Appendix Figure 1. Flow chart for identification of eligible index self-harm episodes and suicide deaths



Area-level characteristics

Travel distance to the nearest hospital emergency department (ED) was extracted from Google Maps; this was defined as the shortest driving distance from the neighbourhood centroid to one of 54 hospital EDs located in New Taipei City or its three neighbouring cities (Taipei City, Keelung City, and Taoyuan City). The locations of these 54 hospital EDs are illustrated in Appendix Figure 2. We included hospital EDs not only in the New Taipei City but also the three neighbouring cities in order to include all the EDs that the residents living in New Taipei City may visit after self-harm.

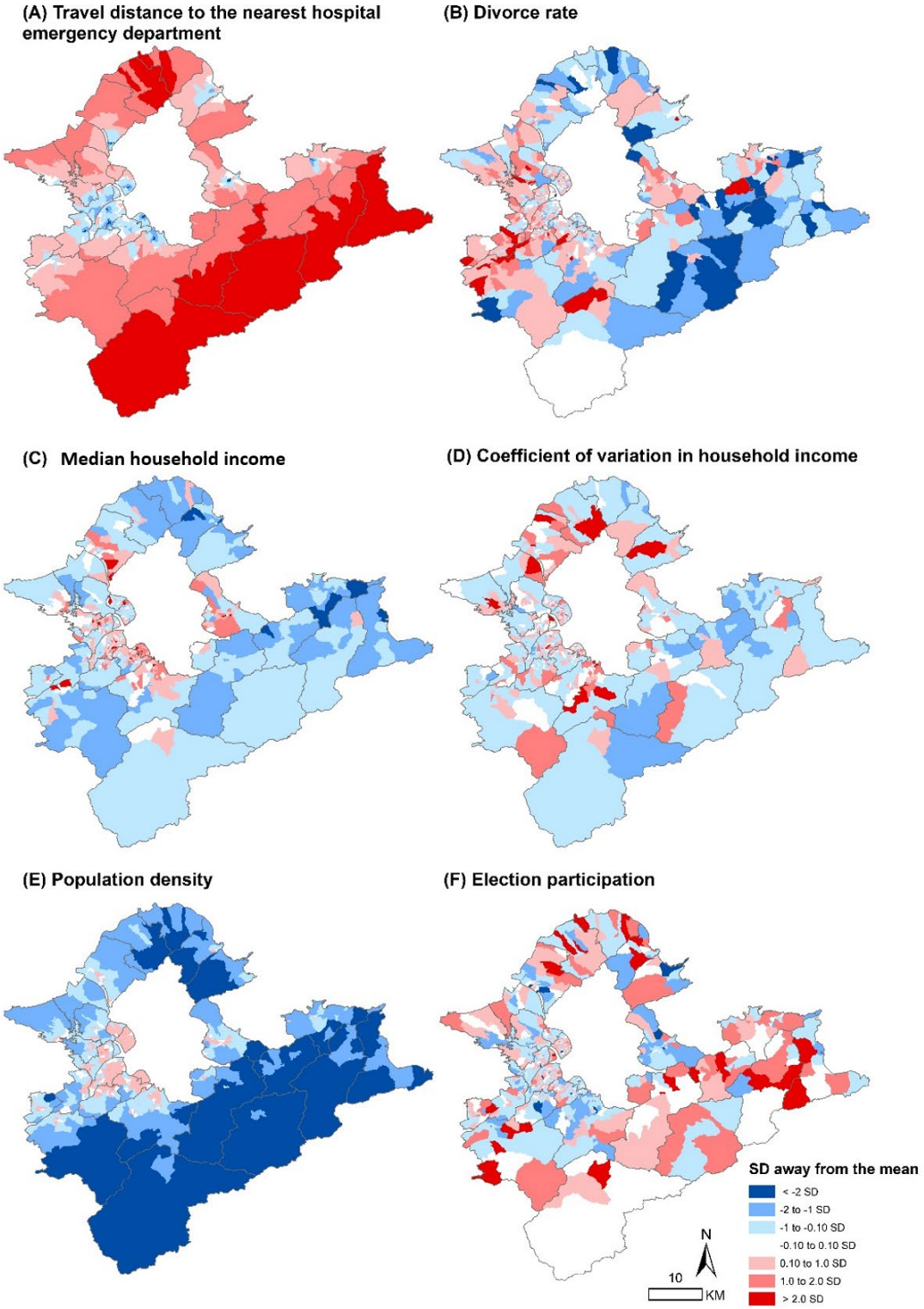
Appendix Figure 2. Location of the study region and 54 hospital EDs within the region



Note: New Taipei City (Appendix Figure 2C), i.e. the study city, is located in northern Taiwan (Appendix Figures 2A and 2B) and is the region around the capital Taipei City (city 2 in Appendix Figure 2B) and adjacent to Keelung City (city 3) and Taoyuan City (city 4). The boundaries of districts in New Taipei City (n=29) were highlighted in bold black (Appendix Figure 1C); the boundaries of neighbourhoods ("li"; n=1,032) were coloured in grey. The locations of the 54 hospitals with emergency department in northern Taiwan were marked as pink squares. The digitalised boundary data files were from the website of the National Development Council Government, Taiwan (https://data.gov.tw/dataset/7438).

Data for a number of area-level characteristics were also collected from the New Taipei City government's websites (Department of Civil Affairs, 2018). We adjusted for the following socioeconomic variables in the regression analyses based on previous studies that reported their associations with area rates of self-harm or suicide (Bambra and Cairns, 2017; Rehkopf and Buka, 2006). Divorce rates in people aged 20 years or above were used as an indicator of social fragmentation; data for divorce rates were extracted from the household registration statistics (2012-2015) (Department of Civil Affairs, 2018). Neighbourhood level of socioeconomic deprivation was measured using median household income. The coefficient of variation in household income was used to represent the neighbourhood level of income inequality. Data for household income were extracted from the Income Tax files (2012-2015) (Ministry of Finance, 2018). Population density, an indicator of urbanisation level (Harriss and Hawton, 2011), was calculated by dividing the population by neighbourhood area. Election participation rates, an indicator of linking social capital (Sundquist et al., 2014), were extracted from the 2014 local election, the only local election held during the study period (Central Election Commission, 2014). Appendix Figure 3 shows the geographic variations in studied area-level characteristics.

Appendix Figure 3. Maps of (A) travel distance to the nearest hospital emergency department; (B) divorce rate; (C) median household income; (D) coefficient of variation in household income; (E) population density; and (F) election participation across 1,032 neighbourhoods in New Taipei City, 2012-2016



Note: The boundaries of districts (i.e. the administrative level above neighbourhoods; n=29) were coloured in grey.

Statistical analyses

The "raw" (unsmoothed) sex- and age-standardised incidence ratios (SIRs) for self-harm and standardised mortality ratios (SMRs) for suicide amongst people aged 10 years or above for each neighbourhood were calculated. We aggregated data over the 5-year study period to ensure sufficient events in small areas. To further address potential statistical instability in estimating small-area SIRs or SMRs, Bayesian hierarchical models were used to estimate the "smoothed" SIRs for self-harm and SMRs for suicide. The models assume a Poisson distribution for the observed number of self-harm or suicide incidents and includes two random effect variables to account for local (structured) and global (unstructured) spatial variability (Besag et al., 1991; Congdon, 1997). The model would "borrow" information from neighbouring areas (local variability) and across neighbourhoods in the study region (global variability) and produce "smoothed" small-area estimates that are statistically more stable and can be used to investigate the "real" geographic variations (Lawson, 2013). Neighbourhoods that share boundaries or vertices were defined as "neighbours."

We examined geographic variations in self-harm and suicide by calculating the mid-90% ratio by dividing the values of smoothed SIRs / SMRs at 95% by those of SIRs / SMRs at 5%. The spatial autocorrelation of SIRs for self-harm and SMRs for suicide was examined using Moran's I using the software package GeoDa (Anselin et al., 2006). We used coefficients of Spearman's rank correlation and the partial rank correlation, after adjusting for travel distance to the nearest hospital ED, to examine the correlation between smoothed SIRs for self-harm and SMRs for suicide. The associations of travel distance to the nearest hospital ED with area rates of self-harm and suicide were investigated using the Bayesian hierarchical models, after adjusting

for other socioeconomic variables. All the area-level characteristics were standardised in the regression analysis. For characteristics with a skewed distribution, log-transformed values were used to calculate the z scores. We examined these studied socioeconomic variables showed no evidence for multicollinearity; the variance inflation factors were all below ten (Cohen et al., 2003). The linearity of associations of travel distance to the nearest hospital ED with rates of self-harm and suicide was investigated by comparing models that included the travel distance as a categorical variable (i.e., deciles) and as a continuous variable (i.e., z scores) using the deviance information criterion (DIC) (Spiegelhalter et al., 2002); a lower DIC value indicates a better model fit. The Bayesian hierarchical models were estimated based on the Markov chain Monte Carlo method (Gilks et al., 1996) using WinBUGS version 1.4 (Spiegelhalter et al., 2003). The convergence of models was assessed using visual inspection of three chains and the Gelman-Rubin diagnostic (Gelman, 2006).

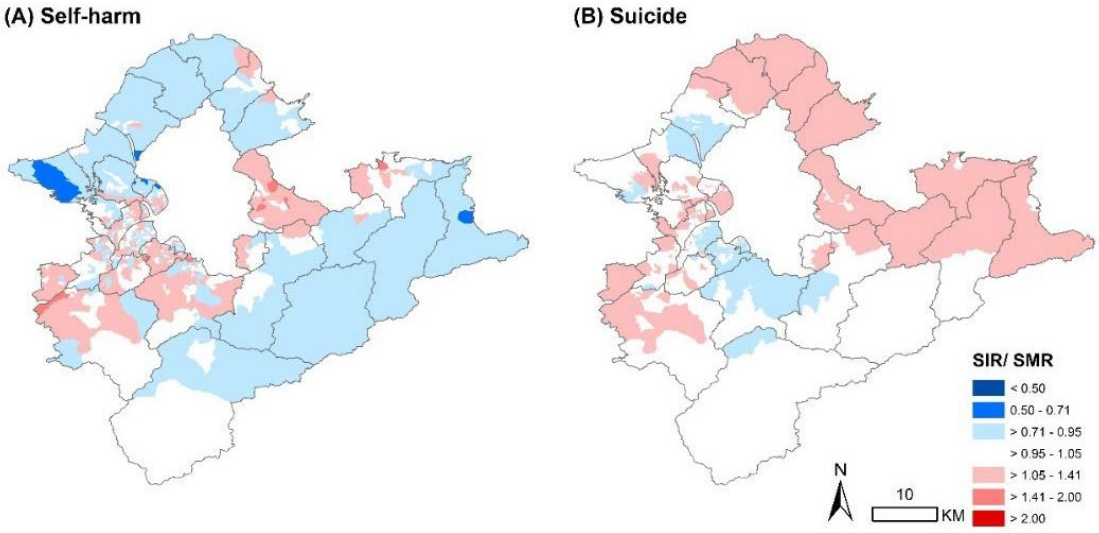
Maps of smoothed SIRs for self-harm and SMRs for suicide were created using ArcGIS 10.6. The values of SIRs and SMRs were grouped into seven categories that are symmetrical on the logarithmic scale around one. The categories were coloured in maps using a divergent red-white-blue colour scheme, with red indicating above-average rate, white indicating near-average rate, and blue indicating below-average rate.

2. Correlations and spatial patterning of area rates of self-harm and suicide

There was a weak positive correlation between neighbourhoods' smoothed self-harm SIRs and suicide SMRs (Spearman's correlation coefficient=0.08, 95% confidence interval [CI] 0.02, 0.15). After adjusting for travel distance to the nearest hospital ED

using partial correlation, the correlation between smoothed self-harm SIRs and suicide SMRs slightly increased to 0.16 (95% CI 0.10, 0.22). In keeping with this, the maps of self-harm SIRs and suicide SMRs showed somewhat different patterning for self-harm and suicide (Appendix Figure 4). For example, the northern and eastern coastal remote areas showed below-average self-harm rates but above-average suicide rates. By contrast, some "central" areas of the city, which mostly had high population density, showed above-average self-harm rates but below-average suicide rates. Nevertheless, some areas showed consistently above- or below-average rates of self-harm and suicide; for example, several areas in the northeastern and southwestern regions showed above-average rates for both self-harm and suicide.

Appendix Figure 4. Maps of (A) smoothed standardised incidence ratios (SIRs) of self-harm and (B) smoothed standardised mortality ratios (SMRs) of suicide across 1,032 neighbourhoods in New Taipei City (2012-2016)



Note: The boundaries of districts (i.e. the administrative level above neighbourhoods; n=29) were coloured in grey.

Moran's I of self-harm SIRs and suicide SMRs were 0.13 ($p<0.001$) and 0.04 ($p=0.005$), respectively, indicating weak spatial autocorrelation for self-harm and suicide across neighbourhoods. After excluding the most extreme 10% values,

smoothed self-harm SIRs and suicide SMRs showed a 1.66-fold (0.60 to 1.27) and 1.4-fold (0.78 to 1.29) difference across neighbourhoods, respectively (Appendix Table 1).

Appendix Table 1. Summary statistics of the distributions of the number of index self-harm episodes and suicide deaths, smoothed standardised incidence ratios (SIRs) of self-harm, standardised mortality ratios (SMRs) of suicide, and Moran's I across 1,032 neighbourhoods in New Taipei City, 2012-2016

	Mean number per area	SD[a]	Min	5%	Median	95%	Max	Sum	Areas with no self-harm episodes or suicides, n (%)	
Number of self-harm	15.8	10.5	0	1	15	35	73	16398	20 (1.9)	
Number of suicide	2.3	1.9	0	0	2	6	11	2328	212 (20.5)	
	Mean	SD	Min	5%	Median	95%	Max	90% ratio[a]	Moran's I	P-value
Smoothed self-harm SIR	1.00	0.15	0.60	0.77	0.99	1.27	1.59	1.66	0.13	<0.001
Smoothed suicide SMR	1.02	0.11	0.78	0.85	1.02	1.20	1.29	1.41	0.04	0.005

SD, standard deviation. [a] Differences over the 90% mid-range, i.e. the values at 95% divided by the values at 5%.

Our data showed a weak correlation between area rates of self-harm and suicide, even after adjusting for travel distance to hospital EDs (partial correlation coefficient=0.16). By contrast, previous studies showed moderate to strong correlations between the self-harm admission rates and suicide rates – Spearman's correlation coefficients were 0.56 across 23 wards in Edinburgh, Scotland (Buglass and Duffy, 1978), and 0.73 across 24 localities in Bristol, England (Gunnell et al., 1995). One important potential factor contributing to the difference in findings was that the two UK studies were based on self-harm hospitalisations and did not include all self-harm ED presentations. Hospitalisation episodes would include more severe injuries or poisonings due to self-harm and thus they could be more similar to suicide deaths in terms of geographic distribution. Additionally, the different findings could

also result from the difference in characteristics and sizes of the study regions - New Taipei City spans more than 2,000 square kilometres, comprising small areas that are very close to or far from the hospital EDs, and those remote areas could have lower rates of self-harm ED presentations due to long travel distance that reduce help-seeking after self-harm. Comparatively, Edinburgh and Bristol have a smaller area, and travel distance to EDs may be a less significant barrier for seeking treatment after self-harm in most areas within the cities. The travel distance factor, which was found to be associated with self-harm rates but not suicide rates in our data, may contribute to the weak association between area self-harm rates and suicide rates in our analysis.

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