Spatial–temporal analysis of suicide clusters for suicide prevention in Hong Kong: a territory-wide study using 2014–2018 Hong Kong Coroner's Court reports

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Summary

Background This study aimed to (i) identify high-risk suicide-methods clusters, based on location of residence and suicide incidence; and (ii) compare the characteristics of cases and spatial units inside and outside clusters.

Methods Suicide data of 4672 cases was obtained from the Coroner's Court reports in Hong Kong (2014–2018). Monthly aggregated suicide numbers based on location of residence, and suicide incidence, were obtained in small tertiary planning units (STPUs). Community-level characteristics and population of STPUs were retrieved from 2016 Census. Retrospective space-time analyses were performed to identify locations with elevated suicide rates over specific time periods, i.e., spatial–temporal clusters. Clusters were evaluated for overall suicide (any method), as well as jumping, hanging, and charcoal burning methods, in location of residence and suicide incidence. Bivariate analysis was performed to compare the characteristics of cases, and spatial units, inside and outside the clusters.

Findings Suicide clusters involving jumping and charcoal burning were identified, but no hanging clusters were found. The within-cluster distribution of types of housing was different from that of outside. For most of the overall suicide and suicide by jumping clusters, spatial units within the clusters were more socially disadvantaged compared to those outside.

Interpretation Clusters varied by suicide methods, location of residence and location of incidence. The findings highlighted the need for consistent and concerted support from different stakeholders within suicide clusters, to ensure appropriate design, implementation and sustainability of effective suicide prevention programs.

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Keywords: Suicide; Suicide prevention; Suicide cluster; Spatial analysis; Spatio-temporal analysis

Introduction

Suicide has been a global public health concern for decades, being responsible in recent years for over 700,000 deaths annually.[1] Preventing suicide should be a public health priority considering its social and economic impacts.[2] Restricting access to suicidal means is an important and effective intervention.[3,4] Recent studies have attempted to identify locations with elevated suicide rates over specific time periods, called spatial–temporal clusters, which can assist in prioritizing suicide prevention actions,[5,6] as these clusters effectively highlight where intervention efforts are most likely to reach a high percentage of people in need.[7] Most studies have focused on identifying spatial–temporal clusters

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Research in context

Evidence before this study

A Scopus search for published peer-reviewed articles prior to 31 January 2023 using the search terms (spatial–temporal OR spatio-temporal OR space-time OR spatiotemporal) AND (suicide) was conducted. Identification of spatial–temporal clusters with elevated suicide risk has been reported in countries such as Australia, the United States, Germany, Spain, etc. Most studies demonstrated variations in suicide risk across the study boundaries, i.e., they showed that suicide clusters existed. However, most research considered suicide clusters based on the location of suicide incidence and we found no research which reported clusters by suicide methods. Furthermore, little research examined differences in characteristics between people who died by suicide and spatial units inside, and outside, suicide clusters.

Added value of this study

This study contributes to the existing literature by providing an example of how to detect spatial–temporal suicide clusters by considering both the locations of residence and suicide incidence, and suicide methods. It used a comprehensive dataset from one region over a five-year period (Coroner's Court data from Hong Kong). The findings highlight the importance of considering residence and suicide incidence locations, as well as methods in suicide cluster detection. Furthermore, *post-hoc* analysis compared characteristics between people who died by suicide and spatial units inside, and outside the identified suicide clusters provided additional insights for suicide prevention efforts in the community.

Implications of all the available evidence

The use of advanced spatial–temporal analysis can assist in prioritizing at-risk locations for suicide in the community, and can inform strategic and targeted intervention efforts. Our study findings highlight the importance of continuous monitoring and evaluation of community suicide risks and needs. They also show how focused and concerted support is required from different community stakeholders to ensure the promotion and sustainability of effective suicide prevention programs.

based on location of suicide incidence.[8,9] Few studies have identified spatial–temporal clusters based on other information, such as location of residence, and suicide methods.[7] Identifying spatial–temporal clusters using multiple sources of information will provide stronger evidence to inform effective community-based suicide prevention programs, particularly in high-risk locations.[10]

Hong Kong is a Special Administrative Region of China with a population of about 7.5 million.[11] The age-standardized suicide rate approximated 10.0 per 100,000 population in 2019 in Hong Kong which was higher than the global average of 9.0.[12,13] Jumping from heights (refer as jumping hereafter) (53%), hanging (25%), and charcoal burning (13%) have consistently been the major methods of suicide in Hong Kong, accounting for over 90% of all suicide cases.[14] Previous studies have documented suicide prevention efforts in high-risk locations in Hong Kong.[15–17] For instance, a multi-level community-based suicide prevention program has been implemented in response to a cluster of suicide deaths of six young adults within four months in the same housing estate.[16] Suicide cluster was no longer detected at the site after the program.

This study aimed to (i) identify high-risk suicide clusters by considering suicide methods, locations of residence and suicide incidence; and (ii) compare the characteristics of suicide cases between high-risk clusters and non-clusters (areas other than those identified as clusters) so as to provide evidence for strategically deploying resources accordingly to implement interventions in specific areas.

Methods

Data source

Data on suicide death from 2014 to 2018 was obtained from the Hong Kong Coroner's Court reports. In Hong Kong, every unnatural death, including suicide, is reported to the Coroner's Court to ascertain the cause of death. Some suspected cases may require coroner's inquest which may take two to three years or even longer to be confirmed as suicide, so 2018 is the latest year with most complete cases for investigation. The information in Coroner's court reports is collected from different sources including family members, police reports and medical examiners. The data is highly valid and has been widely used in studies investigating suicide in Hong Kong.[18–20] Demographic and incident-related information was retrieved on age, sex, marital status (married, never married, cohabiting or divorced/widowed/separated), type of housing in which the people who died by suicide resided (public housing, public subsidized sale flats, private permanent housing or others), whether he/she lived alone, whether there was a history of psychiatric contact, the primary method (jumping, hanging, charcoal burning or others) and place of suicide (building of own residence, hotels/holiday houses or others), year and month of suicide, and resident and incident addresses.

The unit of analysis was the small tertiary planning unit (STPU). The territory of Hong Kong was divided into 214 STPUs during the study period for small-area data release purposes by the Planning Department (range of STPU population: 897–282,047). Monthly numbers were obtained from the Coroner's Court reports, for overall suicides in each STPU, as well as those

suicides which occurred by jumping, hanging and charcoal burning. These were further classified by resident and suicide incident addresses. Suicide cases residing, or occurring in, marine areas, in places outside Hong Kong, or in unknown regions, were excluded from analysis.

STPU-level socio-demographic information was then obtained from the By-census in 2016, which was the year with the most updated small-area level poverty information available, to examine the level of social disadvantage assessed by social deprivation (disadvantage in access towards material or social resources) and social fragmentation (lack of integration or cohesion into society).[21,22] These issues are potentially associated with suicide.[14,23] The following information was retrieved for each STPU: (i) household median income, (ii) unemployment rate, percentages of (iii) poor household (defined as households with monthly income less than 50% of the median monthly income of the corresponding household size), (iv) working poor household, (v) population with secondary education or below, (vi) overcrowded housing (defined as households with more than one person per room), (vii) population with non-professional occupation (defined as non-professional, non-managerial or non-administrative occupation), (viii) single-parent household, (ix) single-person household, (x) single-elderly household, (xi) never-married population, (xii) divorced/separated population (xiii) non-owner-occupied housing, (xiv) households with new arrivals from Mainland China (defined as staying in Hong Kong for less than 7 years), (xv) people with residences different from those five years ago (proxy for mobility). Principal component analysis (PCA) was adopted to construct social deprivation and social fragmentation indices based on variables (i)-(vii) and (viii)-(xv) respectively. The details for constructing the indices have been documented elsewhere.[14] The number of residents in each STPU for the period 2014–2018 was also obtained from the By-census.

Data analysis

Retrospective space-time analysis using discrete Poisson models was conducted using the SaTScan Software (version 10.1, Kulldorff and Information Management Service, Inc.). The space-time analysis employed cylindrical window scanning in which center of the base of the cylinder located on the centroids of the spatial units and the height represented the time intervals of the cluster. The analysis tested the null hypothesis that there were non-differential suicide risks across all STPUs in Hong Kong, whilst the alternate hypothesis tested whether an elevated suicide risk could be detected within the scan window comparing to spatial units outside the window with a significance level (*p*-value) of 0.05 obtaining through Monte Carlo simulation with 999 iterations. For any cylindrical window, if the null hypothesis was rejected, the geographical area was considered as a spatial cluster of elevated suicide risk. Due to the low number of cases in each STPU in one year, the maximum temporal cluster size allowed was set as 50% of the study period (i.e., 30 months).[24–26] The maximum cluster size of 50% of the geographical area was chosen to optimize sensitivity and power.[27] The relative risk was presented as the risk of suicide within the cluster in the specific time period compared to that outside the cluster in the corresponding period. All maps were visualized using ArcGIS 10.8 (Esri, Redlands, CA).

Post-hoc analysis was conducted to examine the difference in characteristics for cluster with more than one unit between (i) the spatial units inside and outside the identified suicide cluster, and (ii) people who died by suicide inside and outside the identified cluster in the specific period and method. The profile of spatial units was indicated by the level of disadvantage which was expressed as quartile of social deprivation/fragmentation (Q1-Q4) with Q1 and Q4 indicated the least and most disadvantage respectively. For comparison between cases inside and outside the cluster(s), differences in sociodemographic characteristics, site of suicide and primary suicide method used (for overall clusters) were examined. Bivariate analyses (t-test, Chi-square test and Fisher-exact test) were conducted. All tests were conducted in R software version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria).

Ethics committee approval

This research was approved by the Human Research Ethics Committee of the University of Hong Kong (EA210305).

Role of the funding sources

Funding sources had no involvement in the study design; collection, analysis or interpretation of the data; in writing of the manuscript or in the decision to submit the manuscript for publication.

Results

There were 4672 suicide cases from 2014 to 2018 in Hong Kong. Information on location of residence was provided for 4388 cases, of which 2315 (52.8%) died by jumping, 955 (21.8%) died by hanging and 564 (12.9%) died by charcoal burning. Location of incidence was provided for 4362 cases, of which 2356 (54.0%) died by jumping, 965 (22.1%) died by hanging and 574 (13.2%) died by charcoal burning. There were 83.6% of people who killed themselves inside their own residential STPU.

Fig. 1a–f shows the suicide clusters by locations of residence and incidence, categorized by three suicide methods of interest. Table 1 describes suicide clusters including time period, STPUs, number of cases,

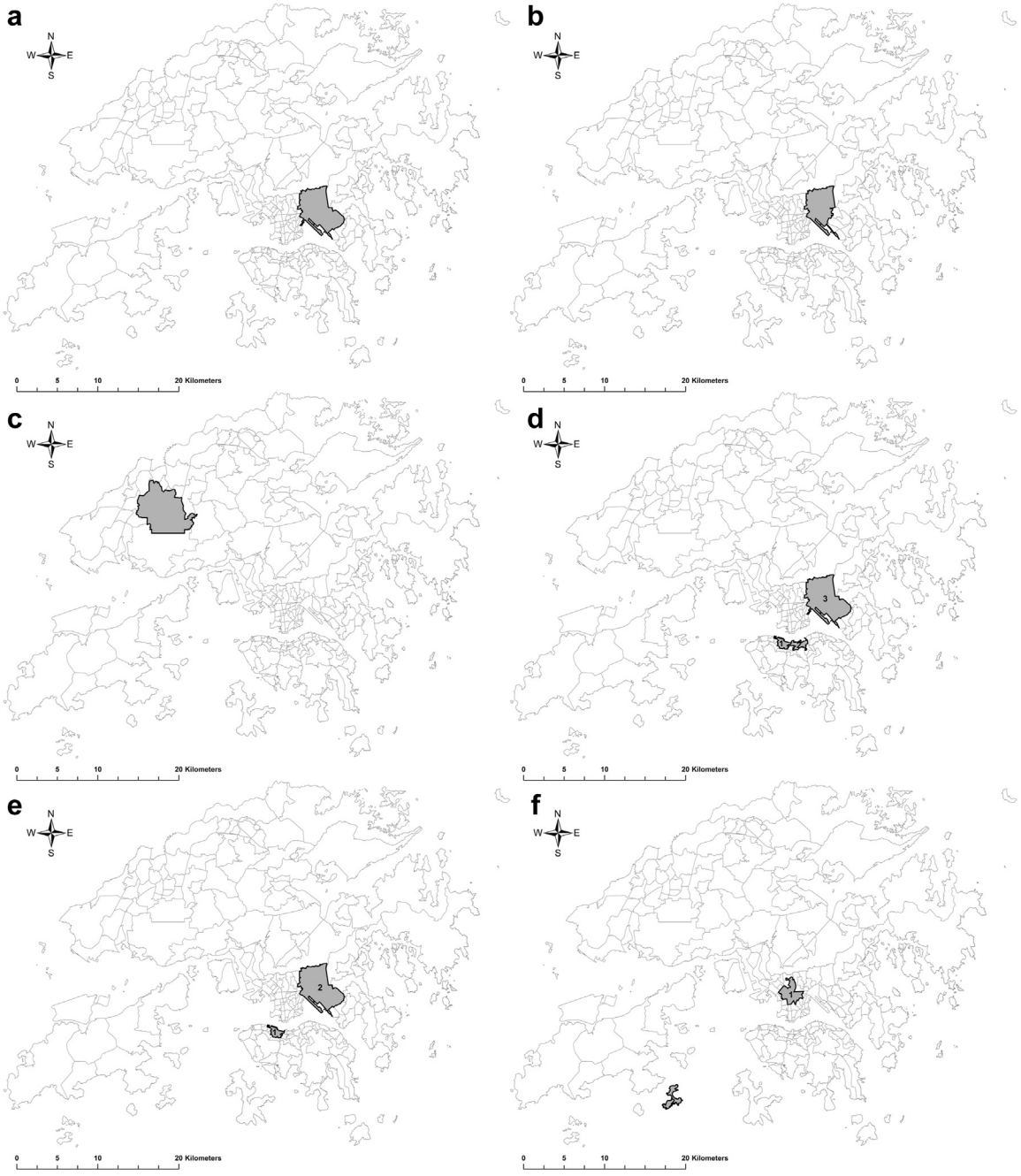

Fig. 1: a. Spatial–temporal cluster of elevated overall suicide risk by location of residence in Hong Kong, 2014/1–2018/12. Note: The location of identified spatial–temporal cluster with elevated overall suicide risk by location of residence is highlighted in grey. b. Spatial–temporal cluster of elevated jumping suicide risk by location of residence in Hong Kong, 2014/1–2018/12. Note: The location of identified spatial–temporal cluster with elevated jumping suicide risk by location of residence is highlighted in grey. c. Spatial–temporal cluster of elevated charcoal burning suicide risk by location of residence in Hong Kong, 2014/1–2018/12. Note: The location of identified spatial–temporal cluster with elevated charcoal burning suicide risk by location of residence is highlighted in grey. d. Spatial–temporal clusters of elevated overall suicide risk by location of incidence in Hong Kong, 2014/1–2018/12. Note: The locations of identified spatial–temporal cluster with elevated overall suicide risk by location of incidence are highlighted in grey. The clusters are numbered with reference to the numbering shown in Table 1 e. Spatial–temporal clusters of elevated jumping suicide risk by location of incidence in Hong Kong, 2014/1–2018/12. Note: The locations of identified spatial–temporal cluster with elevated jumping suicide risk by location of incidence are highlighted in grey. The clusters are numbered with reference to the numbering shown in Table 1 f. Spatial–temporal clusters of elevated charcoal burning suicide risk by location of incidence in Hong Kong, 2014/1–2018/12. Note: The locations of identified spatial–temporal cluster with elevated charcoal burning suicide risk by location of incidence are highlighted in grey. The clusters are numbered with reference to the numbering shown in Table 1.

Cluster	Time	STPU(s) in cluster	Number of cases	Population	Relative risk	*p*-value
Location of residence						
Overall (N = 4388)						
1	2016/08–2018/11	247, 280, 281, 283, 284, 286, 287, 288, 291, 292, 293, 294, 295	344	821,014	1.47	***0.001***
Jumping (N = 2315)						
1	2016/02–2018/04	280, 281, 283, 284, 286, 287, 288, 291	140	515,538	1.89	***0.001***
Charcoal burning (N = 564)						
1	2016/12–2018/04	515, 517, 518, 519, 522, 523, 524, 527, 529	20	208,396	4.34	***0.03***
Location of incidence						
Overall (N = 4362)						
1	2014/02–2016/03	121	13	1720	28.17	***0.001***
2	2015/10–2017/11	132, 133, 134, 135, 146	35	44,608	2.92	***0.03***
3	2016/08–2018/11	247, 280, 281, 283, 284, 286, 287, 288, 291, 292, 293, 294, 295	342	821,014	1.47	***0.001***
Jumping (N = 2356)						
1	2014/02–2016/03	121	9	1720	36.14	***0.001***
2	2016/09–2018/11	280, 281, 283, 284, 286, 287, 288, 291, 292, 293, 294, 295	211	814,117	1.79	***0.001***
Charcoal burning (N = 574)						
1	2014/10–2016/02	220, 221, 222, 227, 228, 229, 231, 232, 233, 234, 235, 266, 267, 268	26	323,838	3.58	***0.028***
2	2016/10–2017/06	920	7	20,361	28.43	***0.003***

Bold and italic indicate that the *p*-value is statistically significant (i.e., $p < 0.05$).

Table 1: **Information of suicide clusters in Hong Kong, 2014/1–2018/12.**

population, relative risk and *p*-value. For location of residence clusters for overall suicide, jumping and charcoal burning were identified. For location of incidence, three overall, two jumping and two charcoal burning suicide clusters were observed. No statistically significant cluster for suicide deaths by hanging was identified, considering either location of residence or incidence.

Results for *post-hoc* analyses (Tables 2 and 3) suggest that the profiles were different between STPUs, and for cases inside and outside the identified clusters. Regarding the individual-level factors, the distribution of types of housing among people who died by suicide within clusters was different from those outside clusters, except for the cluster for location of incidence by charcoal burning (cluster 1). Regarding the clusters for overall suicide methods, and suicide by jumping, based on the location of residence, the proportion of suicide cases who lived in public housing was higher inside clusters (65.4% and 58.6% respectively) compared to outside the clusters (37.3% and 41.0% respectively). A similar profile was identified between suicide cases inside and outside the clusters regarding suicide by any method (cluster 3) and suicide by jumping (cluster 2), based on location of incidence. The reverse was observed for suicide by charcoal burning, based on location of residence, and suicide by any method (cluster 3), based on location of incidence. The proportion of people who lived in private housing was higher in these clusters compared to those outside. For the community-level characteristics, the STPUs inside the clusters for overall methods, and suicide by jumping, were more socially disadvantaged compared to those outside the clusters, when considering location of residence. Similar results were observed for all methods suicide (overall cluster 3) and suicide by jumping (cluster 2), regarding the location of incidence.

Discussion

This is one of the first studies of which we know, to use spatial–temporal analysis to identify clusters with elevated suicide risk by different suicide methods, considering both locations of residence and incidence. Our findings suggest that suicide clusters varied by methods, and locations of residence, and incidence. Further *post-hoc* analysis to profile cases and spatial units would allow a more in-depth understanding of the characteristics of these clusters, and to better inform suicide prevention strategies.

Analysis based on the locations of residence and incidence identified different clusters with elevated suicide risk. Some clusters were identified based on the location of incidence; however, they were not suicide cluster by the location of residence. This can be partially supported by the fact that about 40% of suicide cases in Hong Kong die outside their own home.[28] This finding highlights the importance of considering both the locations of residence and incidence in suicide prevention, not only to identify high-risk areas, but also to identify opportunities for targeted intervention based on a community-based approach. The results also suggested that suicide clusters varied across different time periods. Surveillance of suicide clusters in the community over time is crucial to inform modification of

Suicide case	Overall (2016/08–2018/11)			Jumping (2016/02–2018/04)			Charcoal burning (2016/12–2018/04)		
	Cluster	Non-cluster	p-value	Cluster	Non-cluster	p-value	Cluster	Non-cluster	p-value
	Mean ± SD/N (%)	Mean ± SD/N (%)		Mean ± SD/N (%)	Mean ± SD/N (%)		Mean ± SD/N (%)	Mean ± SD/N (%)	
	N = 344	N = 1753		N = 140	N = 943		N = 20	N = 160	
Age	55.31 ± 20.82	52.71 ± 20.20	***0.03***	54.49 ± 20.68	51.65 ± 20.65	0.13	43.20 ± 15.19	44.65 ± 14.29	0.69
Sex			0.81			0.40			0.95
Male	224 (65.12)	1129 (64.44)		93 (66.43)	592 (62.78)		14 (70.00)	49 (30.63)	
Female	120 (34.88)	623 (35.56)		47 (33.57)	351 (37.22)		6 (30.00)	111 (69.38)	
Marital status			0.80			***0.01***			0.10[a]
Married	145 (42.52)	694 (40.16)		68 (48.57)	374 (39.66)		8 (40.00)	42 (26.25)	
Never married	111 (32.55)	598 (34.61)		43 (30.71)	360 (38.18)		10 (50.00)	69 (43.13)	
Cohabiting	8 (2.35)	34 (1.97)		8 (5.71)	19 (2.01)		1 (5.00)	6 (3.75)	
Divorced/widowed/separated	77 (22.58)	402 (23.26)		21 (15.00)	190 (20.15)		1 (5.00)	43 (26.88)	
Type of housing			***<0.0001***			***<0.0001***			***0.03***[a]
Public housing	225 (65.41)	651 (37.26)		82 (58.57)	387 (41.04)		3 (15.00)	56 (35.22)	
Public subsidized sale flats	59 (17.15)	249 (14.25)		37 (26.43)	177 (18.77)		0 (0.00)	12 (7.55)	
Private permanent housing	50 (14.53)	734 (42.01)		19 (13.57)	335 (35.52)		17 (85.00)	77 (48.43)	
Others	10 (2.91)	113 (6.47)		2 (1.43)	44 (4.67)		0 (0.00)	14 (8.81)	
Living alone	68 (20.12)	367 (21.41)	0.59	18 (12.95)	148 (16.02)	0.35	7 (35.00)	72 (46.45)	0.33
With history of psychiatric contact	128 (37.21)	741 (42.27)	0.08	68 (48.57)	437 (46.34)	0.62	6 (30.00)	51 (31.88)	0.87
Location of incidence			0.40			0.52[a]			0.58[a]
Building of own residence	263 (77.13)	1289 (73.91)		113 (80.71)	726 (77.23)		17 (85.00)	126 (78.75)	
Hotels/holiday houses	4 (1.17)	31 (1.78)		0 (0.00)	4 (0.43)		0 (0.00)	8 (5.00)	
Others	74 (21.70)	424 (24.31)		27 (19.29)	210 (22.34)		3 (15.00)	26 (16.25)	
Primary method			0.07						
Jumping	204 (59.30)	915 (52.20)							
Hanging	71 (20.64)	386 (22.02)							
Charcoal burning	32 (9.30)	229 (13.06)							
Others	37 (10.76)	223 (12.72)							
Spatial units	N = 13	N = 201		N = 8	N = 206		N = 9	N = 205	
Social Deprivation			***<0.001***[a]			***<0.01***[a]			0.33
Q1	0 (0.00)	54 (26.87)		0 (0.00)	54 (26.21)		0 (0.00)	54 (26.34)	
Q2	1 (7.69)	52 (25.87)		0 (0.00)	53 (25.73)		3 (33.33)	50 (24.39)	
Q3	2 (15.38)	51 (25.37)		2 (25.00)	51 (24.76)		3 (33.33)	50 (24.39)	
Q4	10 (76.92)	44 (21.89)		6 (75.00)	48 (23.30)		3 (33.33)	51 (24.88)	
Social Fragmentation			***0.04***[a]			0.09			0.22
Q1	0 (0.00)	53 (26.37)		0 (0.00)	53 (25.73)		0 (0.00)	53 (25.85)	
Q2	3 (23.08)	51 (25.37)		2 (25.00)	52 (25.24)		2 (22.22)	52 (25.37)	
Q3	3 (23.08)	50 (24.88)		1 (12.50)	52 (25.24)		4 (44.44)	49 (23.90)	
Q4	7 (53.85)	47 (23.38)		5 (62.50)	49 (23.79)		3 (33.33)	51 (24.88)	

Bold and italic indicate that the p-value is statistically significant (i.e., $p < 0.05$). [a]Fisher exact test has been conducted instead of Chi Square test due to more than 20% of the expected counts being less than 5.

Table 2: **Characteristics of cases and spatial units between cluster and non-cluster based on the location of residence in Hong Kong, 2014/1–2018/12.**

intervention strategies in response to the changing pattern of suicide methods and/or clusters in society.

Clusters with elevated risks for overall suicide (all methods) and suicide by jumping were identified where the location of residence was similar as the location of incidence. Except for the incidence overall cluster (cluster 2), 75%–80% of cases died in the building where they lived. These areas should be prioritized for suicide prevention programs. The *post-hoc* analysis suggested that these at-risk areas may be more socially disadvantaged, and in most of them, there was a higher proportion of people who died by suicide living in high-rise public housing. About 30% of Hong Kong population lives in public housing.[11] Community-based suicide prevention strategies involving the management body of these buildings, the Hong Kong Housing Authority, which is the major provider of public housing, will be required to evaluate specific community needs and

Suicide case	Overall (cluster 2) (2015/10–2017/11)			Overall (cluster 3) (2016/08–2018/11)		
	Cluster	Non-cluster	p-value	Cluster	Non-cluster	p-value
	Mean ± SD/N (%)	Mean ± SD/N (%)		Mean ± SD/N (%)	Mean ± SD/N (%)	
	N = 35	N = 1893		N = 342	N = 1740	
Age	54.09 ± 25.87	54.45 ± 47.95	0.94	54.98 ± 20.60	53.47 ± 37.86	0.29
Sex			0.06			0.97
Male	17 (48.57)	1215 (64.18)		219 (64.04)	1112 (63.94)	
Female	18 (51.43)	678 (35.82)		123 (35.96)	627 (36.06)	
Marital status			**0.04**			0.83
Married	8 (22.86)	747 (39.46)		141 (41.23)	680 (39.08)	
Never married	12 (34.29)	641 (33.86)		112 (32.75)	592 (34.02)	
Cohabiting	0 (0.00)	50 (2.64)		8 (2.34)	34 (1.95)	
Divorced/widowed/separated	15 (42.86)	455 (24.04)		81 (23.68)	434 (24.94)	
Type of housing			**<0.0001**			**<0.0001**
Public housing	1 (3.03)	752 (40.56)		218 (64.50)	638 (37.51)	
Public subsidized sale flats	0 (0.00)	305 (16.45)		57 (16.86)	247 (14.52)	
Private permanent housing	27 (81.82)	679 (36.62)		52 (15.38)	705 (41.45)	
Others	5 (15.15)	118 (6.36)		11 (3.25)	111 (6.53)	
Living alone	9 (27.27)	381 (20.67)	0.35	71 (21.32)	367 (21.66)	0.89
With history of psychiatric contact	15 (42.86)	761 (40.20)	0.75	129 (37.72)	736 (42.30)	0.12
Location of incidence			**0.02**			**0.01**
Building of own residence	19 (54.29)	1395 (73.85)		263 (77.13)	1290 (74.27)	
Hotels/holiday houses	3 (8.57)	50 (2.65)		0 (0.00)	46 (2.65)	
Others	13 (37.14)	444 (23.50)		78 (22.87)	401 (23.09)	
Primary method			0.13			**0.001**
Jumping	18 (51.43)	1055 (55.73)		217 (63.45)	914 (52.53)	
Hanging	6 (17.14)	399 (21.08)		69 (20.18)	390 (22.41)	
Charcoal burning	3 (8.57)	240 (12.68)		29 (8.48)	240 (13.79)	
Others	8 (22.86)	199 (10.51)		27 (7.89)	196 (11.26)	
Spatial units	N = 5	N = 209		N = 13	N = 201	
Social Deprivation			0.58[a]			**<0.001**[a]
Q1	2 (40.00)	52 (24.88)		0 (0.00)	54 (26.87)	
Q2	2 (40.00)	51 (24.40)		1 (7.69)	52 (25.87)	
Q3	1 (20.00)	52 (24.88)		2 (15.38)	51 (25.37)	
Q4	0 (0.00)	54 (25.84)		10 (76.92)	44 (21.89)	
Social Fragmentation			0.70[a]			**0.04**[a]
Q1	0 (0.00)	53 (25.36)		0 (0.00)	53 (26.37)	
Q2	1 (20.00)	53 (25.36)		3 (23.08)	51 (25.37)	
Q3	2 (40.00)	51 (24.40)		3 (23.08)	50 (24.88)	
Q4	2 (40.00)	52 (24.88)		7 (53.85)	47 (23.38)	
Suicide cases	**Jumping (cluster 2) (2016/09–2018/11)**			**Charcoal burning (cluster 1) (2014/10–2016/02)**		
	Cluster	Non-cluster	p-value	Cluster	Non-cluster	p-value
	Mean ± SD/N (%)	Mean ± SD/N (%)		Mean ± SD/N (%)	Mean ± SD/N (%)	
	N = 211	N = 862		N = 26	N = 145	
Age	53.33 ± 20.38	53.14 ± 38.22	0.92	39.62 ± 11.56	45.79 ± 12.30	**0.02**
Sex			0.29			0.31
Male	137 (64.93)	525 (60.98)		19 (73.08)	91 (62.76)	
Female	74 (35.07)	336 (39.02)		7 (26.92)	54 (37.24)	
Marital status			0.40			0.35
Married	88 (41.71)	341 (39.56)		5 (19.23)	46 (31.72)	
Never married	70 (33.18)	319 (37.01)		12 (46.15)	46 (31.72)	
Cohabiting	7 (3.32)	15 (1.74)		2 (7.69)	6 (4.14)	
Divorced/widowed/separated	46 (21.80)	187 (21.69)		7 (26.92)	47 (32.41)	

(Table 3 continues on next page)

Suicide cases	Jumping (cluster 2) (2016/09–2018/11)			Charcoal burning (cluster 1) (2014/10–2016/02)		
	Cluster	Non-cluster	p-value	Cluster	Non-cluster	p-value
	Mean ± SD/N (%)	Mean ± SD/N (%)		Mean ± SD/N (%)	Mean ± SD/N (%)	
	N = 211	N = 862		N = 26	N = 145	
(Continued from previous page)						
Type of housing			***<0.0001***			0.53
Public housing	130 (62.80)	338 (39.86)		6 (23.08)	54 (37.24)	
Public subsidized sale flats	41 (19.81)	142 (16.75)		3 (11.54)	17 (11.72)	
Private permanent housing	31 (14.98)	329 (38.80)		15 (57.69)	67 (46.21)	
Others	5 (2.42)	39 (4.60)		2 (7.69)	7 (4.83)	
Living alone	35 (17.07)	142 (16.80)	0.93	8 (30.77)	50 (35.21)	0.66
With history of psychiatric contact	93 (44.08)	412 (47.80)	0.33	7 (26.92)	46 (31.72)	0.63
Location of incidence			0.39[a]			***<0.0001***[a]
Building of own residence	157 (74.76)	666 (77.44)		16 (61.54)	132 (91.03)	
Hotels/holiday houses	0 (0.00)	4 (0.47)		8 (30.77)	2 (1.38)	
Others	53 (25.24)	190 (22.09)		2 (7.69)	11 (7.59)	
Primary method						
Jumping						
Hanging						
Charcoal burning						
Others						
Spatial units	N = 12	N = 202		N = 14	N = 200	
Social Deprivation			***<0.0001***[a]			0.07[a]
Q1	0 (0.00)	54 (26.73)		5 (35.71)	49 (24.50)	
Q2	0 (0.00)	53 (26.24)		0 (0.00)	53 (26.50)	
Q3	2 (16.67)	51 (25.25)		3 (21.43)	50 (25.00)	
Q4	10 (83.33)	44 (21.78)		6 (42.86)	48 (24.00)	
Social Fragmentation			***0.03***[a]			0.53[a]
Q1	0 (0.00)	53 (26.24)		3 (21.43)	50 (25.00)	
Q2	2 (16.67)	52 (25.74)		2 (14.29)	52 (26.00)	
Q3	3 (25.00)	50 (24.75)		3 (21.43)	50 (25.00)	
Q4	7 (58.33)	47 (23.27)		6 (42.86)	48 (24.00)	

Bold and italic indicate that the p-value is statistically significant (i.e., $p < 0.05$). [a]Fisher exact test has been conducted instead of Chi Square test due to more than 20% of the expected counts being less than 5.

Table 3: **Characteristics of cases and spatial units between cluster and non-cluster based on the location of incidence in Hong Kong, 2014/1–2018/12.**

provide support to those at risk. Also, of particular concern was the relatively high suicide risk in high-rise building in the central business and financial area in Hong Kong (STPU 121). Some specific measures in identifying those at risk and limiting availability of jumping sites such as setting up fences on bridges and restricting access to rooftops of high-rise might be helpful.

Considering people who died by charcoal burning in cluster based on the location of incidence (cluster 1), about 30% died in hotels or holiday houses, which is much higher than people outside the cluster who used the same method during the same period (1.4%). This suggested an opportunity to promote suicide prevention programs in hotels/holiday houses, such as offering training to hotel staff and the installation of carbon monoxide detectors in hotel rooms and holiday houses.

This study also identified spatial suicide clusters of charcoal burning where previous prevention programs have been employed. For instance, regarding the location of residence cluster for suicide by charcoal burning, part of the area had been involved in a previous quasi-experimental intervention of removing the charcoal packs from the shelves in retail stores in 2006–2007.[29] Although the intervention was shown to be effective at the time, it was not continued and promoted more widely in Hong Kong. Support from the supermarket chain operators did not continue, despite the success of the pilot study, due to concerns of profit losses regarding sales of barbecue charcoal and its related business. In another cluster of suicide by charcoal burning (STPU 920), an intervention program has been implemented targeting suicide by charcoal burning in holiday houses on an offshore island in 2002.[30]

Although the program was initially effective, a long-term evaluation suggested the effects of the program wore off over time.[15] This suggested the importance of continued monitoring and evaluating the community risks and needs, and consistent and concerted support from different stakeholders to ensure the promotion and sustainability of effective suicide prevention programs that targeted specific at-risk areas.

There were no identified clusters for suicide by hanging, considering location of residence or suicide incidence. This indicated that the risk suicide by hanging was distributed relatively evenly over the Hong Kong territory, potentially indicating that hanging was a readily accessible and available method of suicide in the community. Being the second-most common method of suicide in Hong Kong, a specific public health approach may be required to promote suicide prevention by public education and raising the awareness of suicidal risk at the household level, as the majority of hanging occurred at home.[28] Future studies should investigate the characteristics of people who died by different methods, in order to provide insights for developing targeted, effective suicide intervention strategies.

There are several limitations of this study. This is an ecological study which may be susceptible to modifiable areal unit problems (MAUP) in which changing the boundaries of the spatial units may alter the results.[31] The community-level information regarding population and socio-demographic data in each STPU was only available at one time point from the 2016 By-census. Changes in the information over time cannot be captured. The findings of this study do suggest however, the use of spatial–temporal analysis can identify spatial clusters with elevated suicide risk over specific time periods in the community. This method should be adopted more widely to provide evidence for the implementation of different prevention strategies targeted to different locational-methods risks. It should be noted that although suicide clusters have been identified, the number of suicide cases within the clusters accounted for about 20% of all cases using the specific method in the corresponding period. Therefore, besides high-risk prevention approaches targeting suicide clusters, population approach and community-based prevention such as public education, promoting responsible media reporting on suicide and interventions in relatively socially disadvantaged areas are both crucial in reducing suicide and promoting the overall well-being in the society. The timely release of validated suicide data for specific high-risk areas would support a more timely and informed community-based action.[32–34] The government should also consider collecting and updating spatial unit level data more frequently to enhance understanding of important changes in local environments, to facilitate social and public health responses to suicide and other health risks in the community.

Contributors

C.Y. Yeung: conceptualization, formal analysis, visualization, validation, writing-original draft; V.Y. Men: validation, writing-review & editing; Y. Guo: validation, writing-review & editing; P.S.F. Yip: conceptualization, data curation, funding acquisition, software, supervision, validation, writing-review & editing.

Data sharing statement

The data that support the findings of this study are available from Hong Kong Census and Statistics Department and Coroner's Court. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from Prof. Paul Siu Fai Yip with the permission of Hong Kong Census and Statistics Department and Coroner's Court.

Editor note

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Declaration of interests

We declare no competing interests.

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