A network approach to understand co-occurrence and relative importance of different reasons for suicide: a territory-wide study using 2002–2019 Hong Kong Coroner's Court reports

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The Lancet Regional Health - Western Pacific 2023;36: 100752

Published Online 10 April 2023
https://doi.org/10.1016/j.lanwpc.2023.100752

Summary

Background Suicide is a complex and multifaceted issue, and suicidal behaviors are often driven by multiple, interacting factors. It has been challenging to identify reasons for suicide using existing scientific methodologies. This study aims to identify critical reasons for suicide and suicidal behaviors through the application of novel network science methods.

Methods Based on cases investigated by the Hong Kong Coroner's Court from 2002 to 2019, we modelled identified reasons for 13,001 suicide cases as a co-occurrence network, and calculated each reason's eigencentrality to determine their respective relative importance. We then analyzed the temporal and demographic changes in the structure and eigencentrality of the network. We further conducted simulation studies based on the United Nations population projection to assess potential burden of different reasons for suicide on the population in the coming years.

Findings School-related issues had the highest eigencentrality (eigencentrality = 0.49) for individuals younger than 20 years of age. Financial issues were crucial for adults aged 20–59 years, but their importance differed between males (eigencentrality = 0.51) and females (eigencentrality = 0.14). Physical illness (eigencentrality = 0.80) was the core concern for adults over 60 years. Across the Hong Kong population, the reasons for suicide appear to have shifted from financial issues in the early 2000s (eigencentrality = 0.46) to issues related to physical illnesses since 2011 (eigencentrality = 0.58). Simulation findings indicate that, by 2050, most suicides in Hong Kong will be due to physical illness-related issues (eigencentrality = 0.69) due to the rapidly aging population.

Interpretation There have been important sex and age differences over time, in reasons for suicide. Given the projected increasing age of the Hong Kong population over the next decades, older adults with physical illnesses appear to be the highest contributors to suicide cases in the overall population. This novel network analysis approach provides important data-driven information upon which to base effective proactive public health suicide prevention strategies and interventions.

Funding Hong Kong Jockey Club Charities Trust, Collaborative Research Fund (C7151-20G), and General Research Fund (17606521).

Keywords: Forecasting; Network science; Suicide

Introduction

Suicide has long been a leading cause of premature mortality worldwide, making it a critical public health issue for modern society.[1–4] Suicide is the leading cause of age-standardized years of life lost in high-income Asian Pacific societies, and has been among the

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Research in context

Evidence before this study

We searched PubMed and Web of Science up to November 11, 2022 with search terms (reasons for suicide) AND (co-occurrence OR comorbid) without language restrictions between 2013 and 2022. Thirty works from PubMed and 31 from Web of Science were identified. Though plenty of reasons for suicide research have been conducted, the co-occurrence of reasons for suicide is barely discussed. The majority of current research works usually focus on a specific group of people and/or comorbid with specific reasons for suicide, but the co-occurrence of other reasons for suicide is less mentioned.

Added value of this study

This is the first population-based study to analyse the reasons for suicide across over 15 years in Hong Kong. We adopt a novel network approach, which considers the co-occurrence of multiple reasons for suicide, to quantify the reasons for suicide from the Coroner's Court in Hong Kong from 2002 to 2019. This approach identifies the critical reasons for suicide, which usually co-occur with other reasons, quantitatively, and forecasts the reasons for suicide in the future. The network suggests that school issues, financial issues, and physical health issues play a critical role in suicide for those below the age of 20, working-age adults, and older adults respectively. The simulation and findings also suggest a population-based approach to tackle the increasing older adults suicide cases in the aging society.

Implications of all the available evidence

The network approach enables a quantitative tool for forecasting future reasons for suicide under the population structure change. The forecast results suggest that older adults' suicide would become more serious in the near future as Hong Kong steps into a super-aged society. This network-based approach can also give other countries a reference for how aging society changed the reasons for suicide.

highest contributors to mortality in other regions of the globe.[2] Hong Kong itself has seen between 900 and 1000 deaths by suicide every year within the past decade, and suicide is currently the leading cause of death among young people aged 15–24 years.[5]

Theories and conceptual frameworks, such as the biopsychosocial model of suicide,[6–8] posit that the mechanisms and pathways that lead to suicide attempts are multifaceted. On one hand, risk factors such as sex and socioeconomic status,[9] chronic disease,[10] and psychiatric disorders,[11] have long been linked to suicidality. Additionally, age- and gender-specific risk factors for suicide have also been identified, such as financial stress and physical illness among adults aged 50 years and older,[12] and gender inequality leading to higher female suicide rates.[13] On the other hand, suicide is a complex phenomenon.[14] For some individuals it may be precipitated by a single reason, whereas in other people, there are clusters or co-occurrences of underlying reasons which may differ across population subgroups. While the co-occurrence of multiple reasons has been acknowledged previously,[15,16] research has yet to clearly delineate how interrelations between multiple reasons for suicide should be accounted for, when formulating suicide prevention strategies from a population health perspective.

Little current research has focused on the co-occurrence of reasons for suicide. Most of the current population-based studies have focused on a specific dimension of reasons for suicide (e.g., mental or physical health).[9–11] There are three studies that focused on the relationship of multiple reasons for suicide: one adopted a quasi-Poisson regression for each reason for suicide to estimate excess suicide rates,[17] while the other conducted in-depth interviews with the victims' close relatives.[18] The quasi-Poisson model does not discuss the co-occurrence of the reasons for suicide although the researchers have reported this observation. The in-depth interviews confirmed that suicide is a complicated issue often involving several reasons, but little quantitative evidence was provided to support this argument. Shiratori et al.[19] adopted a network science approach to address the co-occurrence similar to this work. Nonetheless, detailed comparison between different gender, age, and time was not addressed. Consequently, researchers have largely been unable to objectively attribute the relative importance of individual reasons to the overall burden of suicide in populations, nor have they been able to pinpoint which specific area(s) warrant more urgent policy attention and/or intervention. This has impeded policy-makers' capacity to allocate limited available resources for cost-effective suicide prevention strategies. Network scientists have made strides in various public health challenges, such as increasing uptake of healthy behaviors,[20] and enhancing cost-effectiveness of vaccination strategies,[21] by framing them as network problems and identifying appropriate network properties to be intervened. However, the use of networks to address reasons for suicide co-occurrence has not been as common.

This study aims to objectively quantify the relative importance of reasons for suicide using a novel network science approach, using suicide cases recorded over the period 2002–2019 in Hong Kong.

Methods

Data source

Data for this study was obtained from the Hong Kong Coroner's Court reports. In Hong Kong, all unnatural

deaths (including suspected suicides) must be investigated by the Coroner's Court by law to ascertain the cause of death, as outlined in the Coroners Ordinance (Cap. 504).[22] Hence, the Coroner's Court information constitutes the most comprehensive source available to identify deaths involving suicide within the Hong Kong territory. Once a death is reported, investigations and inquests are held to determine the cause and circumstances surrounding the death.[23] The police are responsible for investigating every death reported to the Coroner,[23] where they may interview close relatives and friends, and consider evidence such as suicide notes or internet chat histories. The duration of the process varies from three months to twelve months, and all deaths are coded according to the International Classification of Diseases and Related Health Problems, 10th Revision (suicides are recorded under codes X60–X84).[23] Suicide is determined as the cause of death only if the Coroner's Court can reasonably eliminate the possibility of accident, homicide, or other causes. Inquests may also be held with or without a five-person jury, who decide on the circumstances regarding the death.[22] Reasons for suicide, as concluded by the Coroner's Court, were classified into eight categories (Supplementary materials e-Table S1)—family (FAM); relationships (REL); school (SCH); work (WORK); financial (FIN); abuse (ABU); physical illness (PHY); and mental disorders (MENT). Of note, any kind of assisted suicide is considered a criminal act in Hong Kong, and is not categorized as a suicide case.

With consent from the Coroner's Court, we obtained all suicide death case reports issued from January 1, 2002 to December 31, 2019, identifying 17,546 cases. However, the reason(s) for suicide were not provided for 4545 cases, and they were subsequently excluded from our analysis. Thus, 13,001 cases were used in this study, including 4573 cases (35.17%) who left suicide notes. Ethics approval was obtained from the Human Research Ethics Committee of the University of Hong Kong (EA210305).

Constructing the suicide co-occurrence network

The analytical methodology for this work was inspired by co-occurrence in addressing multiple existences in microbiome clusters fields.[24] Constructing a co-occurrence network and calculating network centrality measures allows researchers to investigate the relative importance of key nodes (organisms) in the network. In order to explore the multifaceted nature of suicide causes, we formulated a "reasons for suicide co-occurrence" (RSC) network with each identified reason in the Coroner's Court reports conceptualized as a node, and the frequency of co-occurrence between two reasons as a weighted edge/link between the two. The relative importance of each reason was assessed using nodes' centrality measurement.

The network approach explicitly models the co-occurrence of suicide reasons which is rarely addressed in traditional general linear model and descriptive analyses. Within the current study's context, the RSC network is defined by a $k \times k$ undirected weighted symmetric adjacency matrix A. The set of nodes $N = \{N_i | i = 0, 1, ..., k\}$ represents distinct reasons for suicide ($k = 8$ in this study), and the set of edges $a = \{a_{ij} | i, j = 0, 1, ..., k\}$ stands for the co-occurrence of reasons i and j in a suicide case.

We defined the weight of edge a_{ij} as the number of individuals who committed suicide due to reasons N_i and N_j. The edge a_{ij} is the i th row and j th column of the adjacency matrix A. Greater edge weight indicated that its corresponding pair of reasons for suicide occurred more frequently. In particular, the following rules were applied to each considered suicide case in order to construct the adjacency matrix A:

1. If a suicide case results from a single reason N_i, then the weight of the self-pointing edge a_{ii} will be added by 1.
2. If a suicide case results from multiple reasons N', $N' \in N$, where N' represents a set of 2–8 of the possible distinct reasons in the Coroner's Court reports, then all the edges not on the diagonal line $\{a_{ij} | i \neq j; i, j \leq k\}$ that connect to any of the reasons in N' will be added by a value of $\frac{1}{\binom{|N'|}{2}}$, where $|N'|$ is the cardinality of N', i.e., the number of reasons for the particular suicide case.

The above two rules ensure that each suicide case uniformly adds a weight of 1 to the network, and that in cases with multiple reasons for suicide, each reason adds the same weight. For a suicide case with multiple reasons for suicide, it will pose the weight on $\binom{N'}{2}$ edges according to the rule 2. While this weight is the reciprocal of $\binom{N'}{2}$ then it will evenly distribute to all the nodes and increase the total amount of weight 1 to the whole network, which has the same effect on single reason of suicide case. For example, for a case with family issues, financial issues, and mental health issues as suicide reasons, all 3 edges $\binom{3}{2}$ would have the same weight of $\frac{1}{3}$ ($\frac{1}{\binom{3}{2}}$), such that the total amount of the weight added to the network would equal to 1, the same effect as that of a suicide case with just a single reason.

Eigencentrality

Normalized eigencentrality was used to measure the relative importance of each reason for suicide in the

RSC network. Each node in the network was assigned a relative score based on its frequency, i.e., weight of self-pointing edge, as well as the weights of edges with its neighboring nodes, such that nodes that occurred more frequently and co-occurred with other frequently-occurring nodes would have higher values of normalized eigencentrality.

The standard procedure when calculating nodes' eigencentrality values is to use the network's adjacency matrix A. Here, we calculated the eigenvector x as the product of the eigendecomposition of A, such that the following form is satisfied given the constant scalar λ:

$$Ax = \lambda x$$

The normalized eigencentrality is specified as the solution x^{norm} such that:

$$\sum_i x_i = 1$$

The normalized eigencentrality x_i^{norm} of node N_i is then the i^{th} component of the normalized eigenvector x^{norm}. Accordingly, nodes with the highest values of x_i^{norm} can be interpreted as those with the highest importance towards the overall burden of suicide in the population to which the constructed RSC network corresponds. Furthermore, the normalized eigencentrality could be compared between different RSC networks to show the relative importance changes for the same reasons for suicide.

For more fine-grained analyses, specific co-occurrence networks were constructed for different demographic subgroups, and analyzed following the general procedures described above. A network was constructed for 20-year age groupings (0–19 years, 20–39 years, 40–59 years, 60–79 years, and 80+ years). Sex-specific analyses within each age group were further conducted. Temporal aspects of the RSC networks were constructed in three-year intervals from 2002 to 2019.

All data analyses and simulation in this study were performed using Python with networkx package.

Simulation as a prediction of reasons for suicide co-occurrence

The network approach allows for simulating suicide co-occurrence with different population structures. Based on the RSC network calculated from our data and projected demographic trajectories of the Hong Kong population, we conducted simulation studies to investigate anticipated relative importance of different reasons for suicide so as to present informed suggestions on strategic directions for population-level suicide prevention strategies. First, we constructed the sex- and age-specific suicide co-occurrence rate adjacency matrix $A^{age,sex}$ from the Coroner's Court reports and population statistics obtained from the Census and Statistics Department.[25] We then defined the co-occurrence rate adjacency matrix as the co-occurrence matrix divided by the population in the corresponding age group. This was then used to project a *future suicide co-occurrence matrix*.

The projection of future suicide co-occurrence matrix was developed by taking the population co-occurrence rate adjacency matrix and multiplying the corresponding sex- and age-specific population estimation at the specified time-point based on the population projection estimated by the United Nations[26]:

$$A^{year} = \sum_{sex=F,M} \sum_{age} A^{age,sex} p^{age,sex}$$

In this sense $A^{age,sex}$ denotes the suicide rate due to different reasons for suicide at the specific age- and sex-group. Consequently, given the population structure $p^{age,sex}$, we could simulate the future RSC network for the overall population. We conducted the simulation for the year 2050 using the current suicide rate from the 2011–2019 Coroner's Reports to estimate future reasons for suicide. The RSC network enables a deeper understanding of the reasons for changing suicide patterns in line with shifting demographics. Codes with interactive interfaces to simulate the different future scenarios under various parameters are available at https://github.com/YuChengHSU/cc_report.

Results

Descriptive statistics

Of the 13,001 suicide cases available for analysis, there were twice as many males (8165) as females (4836). The mean age for suicide cases was 50.9 years (standard deviation [SD] = 21.0 years), with the youngest and oldest suicide cases being 8 years and 105 years, respectively. There were no sex differences in mean suicide age (males 50.9 years (SD = 21.7), females 50.8 years (SD = 19.7); see Table 1). Some 40% of suicide cases were triggered by multiple reasons (Supplementary materials e-Table S2).

Relative importance of different reasons for suicide

Findings for suicide reasons in Hong Kong suicide population subgroups, as well as their temporal trends, are presented below. In the figures that follow, a node's size denotes the frequency at which its corresponding reason for suicide was reported over a specified period, while edge thickness between a pair of nodes denotes the frequency of co-occurrence of their corresponding reasons for suicide.

Fig. 1 illustrates temporal changes of the RSC network based on the total 13,001 records from 2002 to 2019, and the normalized eigencentrality for the suicide reasons. The relatively large node sizes for financial reasons (FIN) for networks corresponding to the early 2000s indicates that there were more suicides due to solely financial reasons in those years. However, the node size of FIN had been decreasing since 2002.

	Overall (N = 13,001) n (%)	Male (N = 8165) n (%)	Female (N = 4836) n (%)
FAM	3860 (29.7)	2179 (26.7)	1681 (34.8)
REL	1221 (7.0)	665 (6.0)	556 (8.6)
SCH	286 (1.6)	163 (1.5)	123 (1.9)
WORK	1098 (6.3)	730 (6.6)	368 (5.7)
FIN	3706 (21.1)	2856 (25.7)	849 (13.2)
ABU	508 (2.9)	410 (3.7)	98 (1.5)
PHY	4135 (23.6)	2640 (23.8)	1495 (23.2)
MENT	3011 (17.2)	1499 (13.5)	1511 (23.5)

Table 1: **Reasons for suicide deaths as reported in the Coroner's Court reports (N = 13,001).**

Furthermore, the decrease in the eigencentrality for FIN within the same time period implies that financial reasons had become a relatively less important contributor towards the burden of suicide on the population. On the other hand, the eigencentrality values for physical and mental issues had been increasing since 2011.

Fig. 2 shows how the RSC network varied across age groups. The large node size and high eigencentrality values for school (SCH; eigencentrality = 0.43) and family (FAM; eigencentrality = 0.26) issues for the 0–19 years age group indicate that these two reasons were the most important precipitating factors for suicide among children and adolescents. In contrast, financial issues (FIN) were the single most important reason for suicide among working-age adults (eigencentrality = 0.34 and 0.39 respectively for age groups 20–39 years, and 40–59 years). For older adults, the most important reasons behind suicide were physical health issues (PHY; eigencentrality = 0.68 and 0.76 for age groups 60–79 years and 80+ years respectively) and family issues (FAM; eigencentrality = 0.14 and 0.17 for age groups 60–79 years, and 80+ years, respectively). Furthermore, Fig. 2 demonstrates that family issues were prevalent in suicide cases across all age groups, as it consistently had the second or third highest eigencentrality.

Fig. 3 illustrates the eigencentrality values of the reported reasons for suicide in co-occurrence networks corresponding to age groups stratified by sex. While the most important reasons for suicide were consistent for both males and females younger than 20 years, or older than 59 years, the reasons differed between males and females aged between 20 and 59 years. Financial issues (FIN) had the single highest mean eigencentrality for males from 2002 to 2019 (0.44, SD = 0.08), compared with a mean eigencentrality value of 0.15 (SD = 0.11) for females. The mean eigencentrality difference between males and females is 0.29 (t-test $p < 0.001$). Mental health (MEN) was a more important reason for suicide among females than males in the same age group (mean eigencentrality for females 0.37, SD = 0.22; males 0.15, SD = 0.10).

Fig. 4 illustrates the temporal trends of eigencentrality values of the eight reasons for suicide among (A) individuals below 20 years of age (B) 20–59-year-old males (C) 20–59-year-old females, and (D) individuals 60 years of age or older. An increasing eigencentrality for mental health issues among working-age females can be observed over the years from 2002 to 2019, whereas those related to financial reasons among working-age males remained relatively high (from 0.35 to 0.56) from 2002 to 2019. Decreasing eigencentrality values for family-related reasons for suicide among individuals 60 years of age or older can also be observed from 2002 to 2019.

Simulation to predict future suicide cases

Fig. 5 illustrates the simulated RSC network for Hong Kong's projected population in 2050 (Supplementary materials e-Fig. S1), assuming suicide rates across sex-age groups remain unchanged, as the period of 2011–2019. This is the most stable time period for suicide rates and reasons for suicide, and was identified from Fig. 1 for simulation purposes.

As of 2021, 27.9% of the Hong Kong population was aged over 60 years.[25] If Hong Kong society ages as projected, by 2050 more than 40% of the Hong Kong population will be over 60 years old. Simulation results in Fig. 5 indicate that under this projected scenario and assuming that currently-observed reasons for suicide rates across sex-age groups remain unchanged, physical illnesses will become the most common reason for suicide in the overall population, both in cases with only one reason (as reflected by the size of node PHY being the largest among all other nodes), and also in cases with co-occurring reasons (as reflected by the thickest edges connected to the PHY nodes). An eigencentrality of 0.70 for PHY also indicates that physical illnesses will be the most important contributor to the overall burden of suicide on the population, overshadowing all other reasons for suicide. To put this in perspective, the reason for suicide with the second highest eigencentrality, mental health, has a much smaller eigenvalue (0.17). Thus, due to the increasing proportion of older adults in the population, it appears their physical illness concerns will overtake and possibly dilute all the other reasons for suicide, even though those other reasons remain common in younger age groups.

Discussion

This paper is the first to present a network science approach to analyze over 18 years of Coroner's Court reports on suicides in Hong Kong. This approach provides new perspectives and metrics for understanding the relative importance of different reasons for suicide. Our findings demonstrate how interrelations between multiple reasons for suicide could be accounted for, and

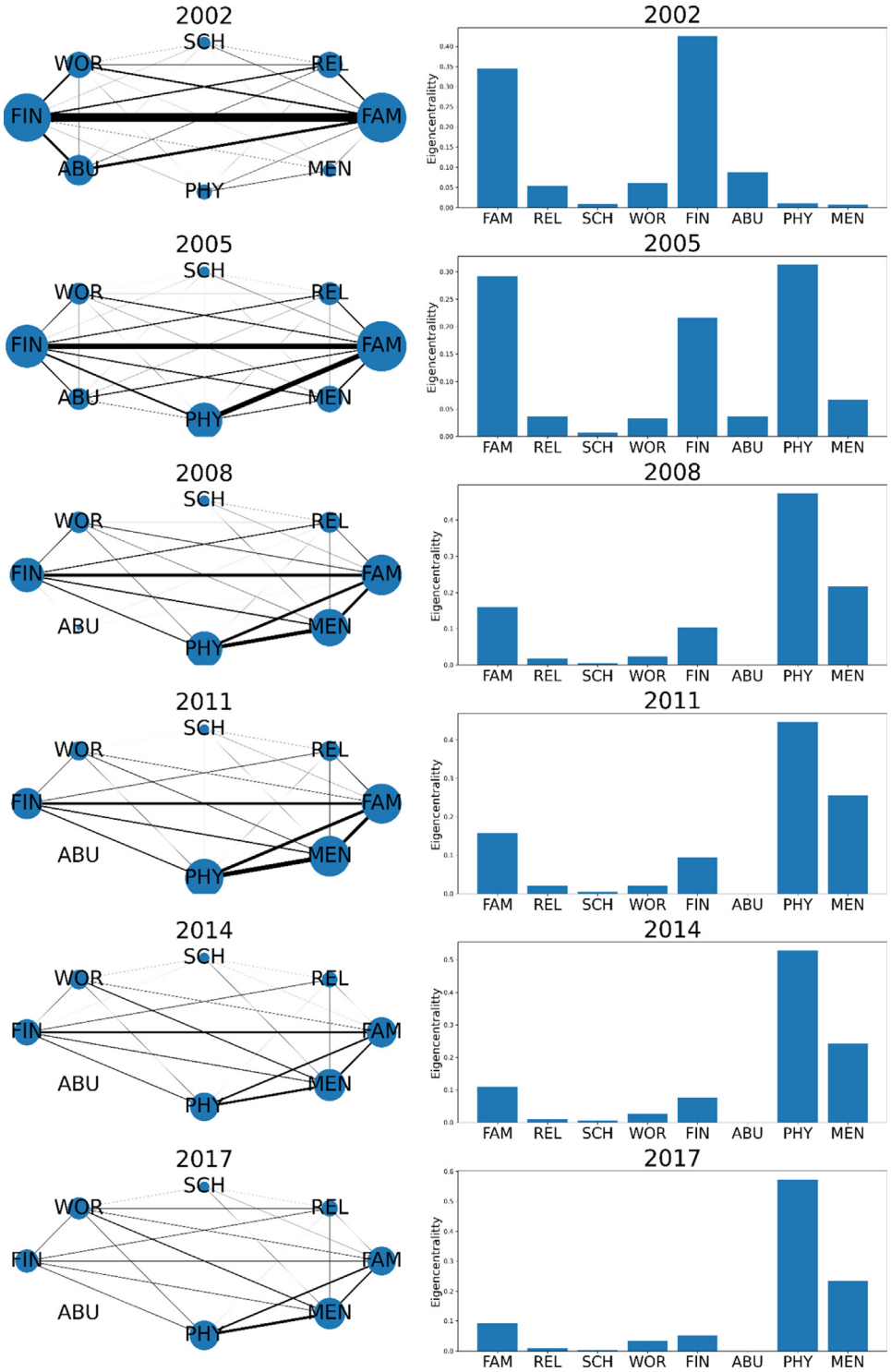

Fig. 1: Changes in the RSC network that corresponds to 13,001 records from 2002 to 2019. Each graph represents a three-year co-occurrence network starting from the captioned year, e.g., 2002–2004, 2005–2007, etc. Node size reflects the frequency of single-reason suicide cases.

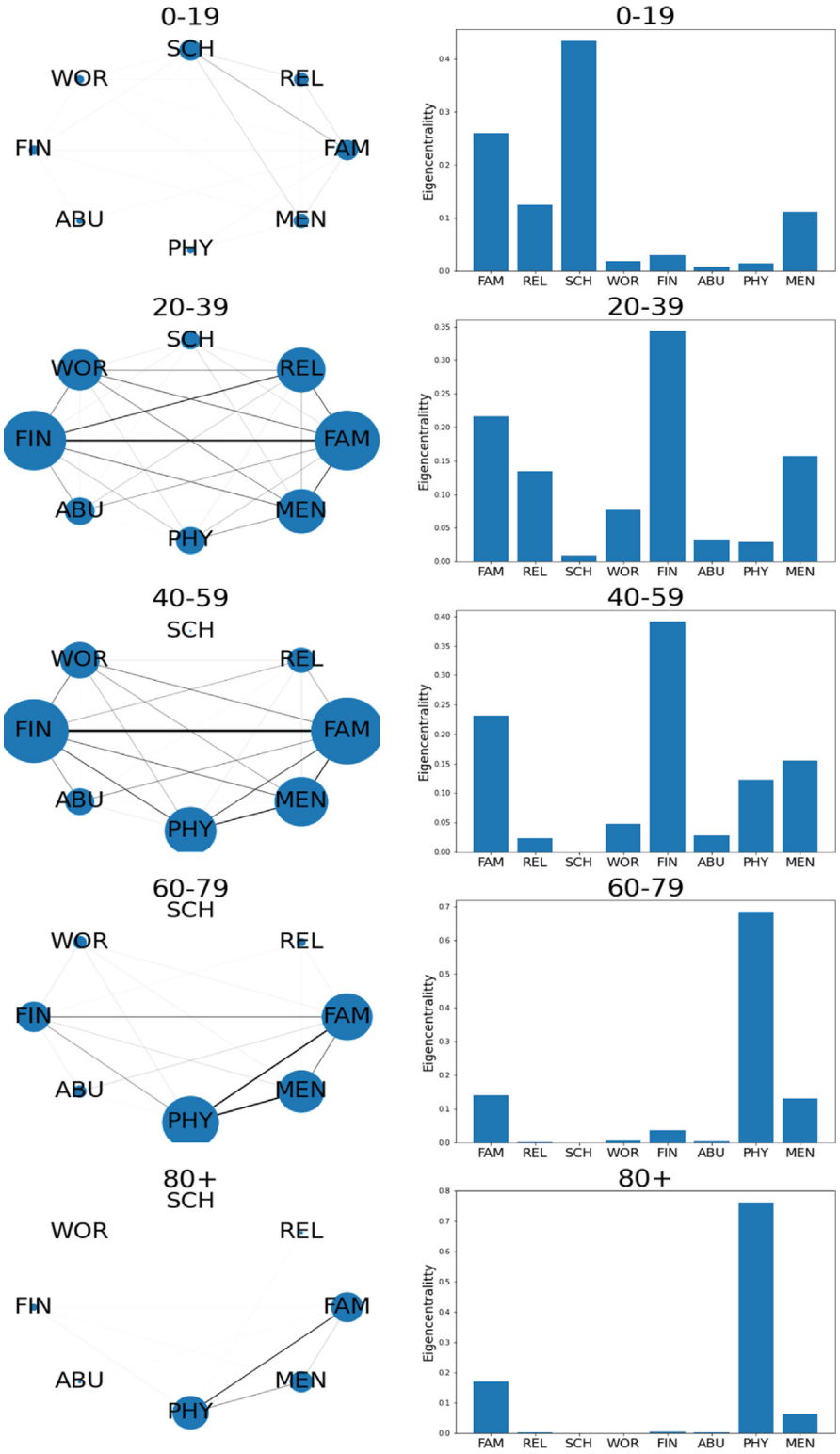

Fig. 2: RSCe network over the period 2002–2019 for different age groups. Each network corresponds to a specific age group. Node size reflects the frequency of single-reason suicide cases.

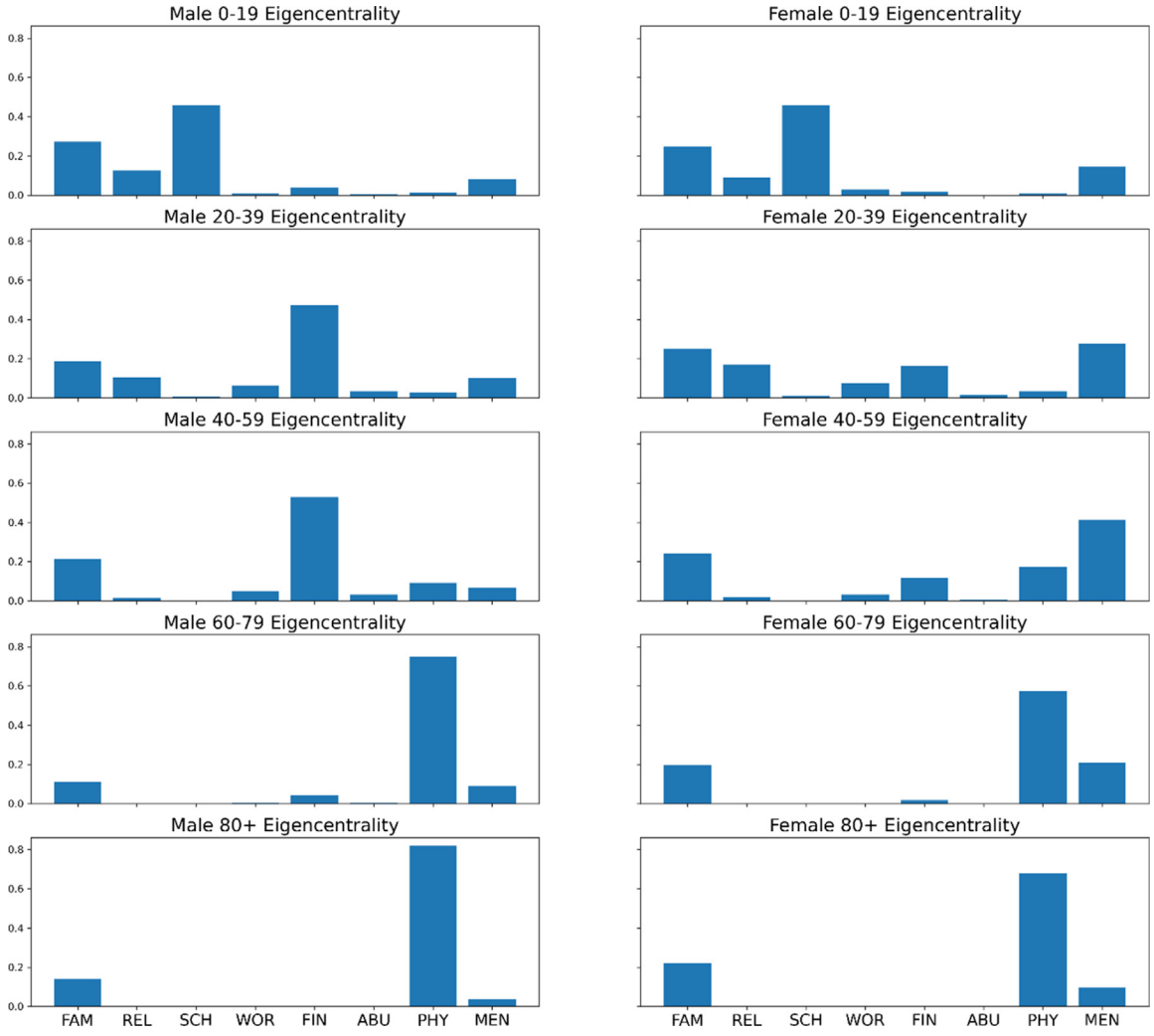

Fig. 3: **Normalized eigencentrality for RSC networks in different age and sex groups within the period 2002–2019.**

how the information could inform population-wide suicide prevention strategies.

Eigencentralities calculated from the RSC networks allow for identification of the significant reasons for suicide in different periods, and sex-age groups. Though previous research identified the RSC networks, it did not explicitly report on how to construct the network with RSC,[19] and deteriorate the interpretation of centrality metrics. The network science approach presented in this paper appears to effectively account for both single-cause and multi-cause suicide cases. It thus provides a quantitative toolbox to better identify priority targets and their associated reasons for suicide that have the highest potential for reducing the overall burden of suicide on the population.

The primary drivers of suicide differ across age and gender subgroups in the Hong Kong population, and highlight the importance of subgroup-specific suicide prevention initiatives. For example, our findings concur with previous studies which found that school and family issues are the primary reasons behind suicide cases among children and adolescents.[27–31] While adolescence is a life stage where individuals explore their independence and develop their own identities by learning from their social relationships,[31,32] within Hong Kong contexts, this psychosocial development phase may often be in conflict with parent-imposed emphasis on academic performance. Thus, school issues in Hong Kong adolescents may result in conflicted parent-child relationships that increase adolescents' suicide risk.[29,33]

On the other hand, that financial reasons are the main driver for suicide by 20–59-year-olds is unsurprising, given that this age group is typically primarily occupied with economic activities.[34] Thus experiencing financial difficulties during this life stage could reasonably cause significant psychological distress.[35]

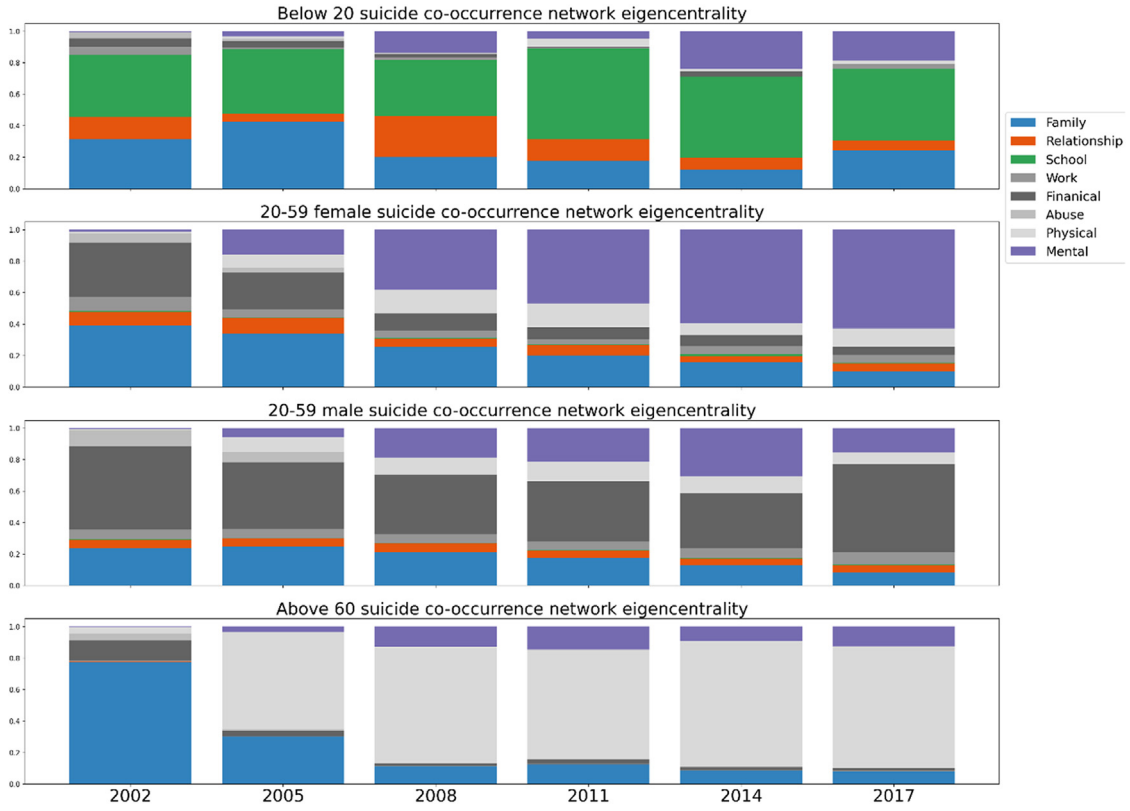

Fig. 4: **Normalized eigencentrality for RSC networks in the different groups from 2002 to 2019. Each column represents a three-year time interval starting from the captioned year.**

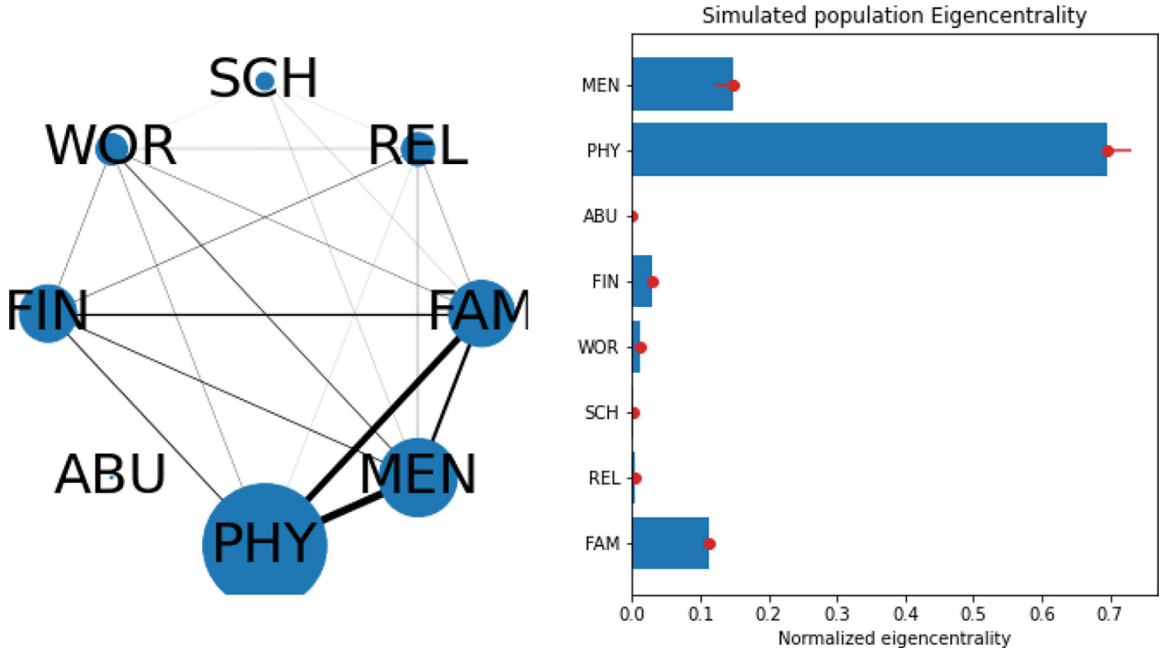

Fig. 5: **(Left) Simulated RSC network for Hong Kong's projected population in 2050 based on the latest available suicide co-occurrence matrix. (Right) normalized eigencentrality of each reason for suicide; red bars indicate the range of eigencentrality value estimates based on the 95% upper and lower bounds of population estimations.**

Unlike findings from a previous study on British working-age individuals where men and women suffered equally,[36] our findings are that financial difficulties are more likely to be attributed by the Coroner's Court to be the main cause of suicide among working-age males than females, echoing the same pattern observed among working-age Koreans.[35] This may point towards broader East Asian cultural and sex-age norms which require men to be the primary breadwinners in the family. Nevertheless, as Hong Kong becomes an ageing society, financial reasons for suicide will likely become less important compared to physical illness-related reasons.

The increasing frequency of suicide cases resulting from physical illnesses, supported by its strong eigencentrality in the overall population, coincides with the fact that Hong Kong's population has been rapidly aging since 2002, with people aged 60 years and older making up 28.6% of the total population by the end of 2021.[25] Chronic illness in older adults is common; over 64% of them suffer from at least one chronic illness in Hong Kong.[37] Moreover, in Hong Kong, older adults generally live by values influenced by traditional Chinese culture, and many are financially supported by their family.[38] Thus they may see themselves as a burden to their family should they suffer from chronic,[10,39] or severe illnesses,[40] and require additional support.[41] In such situations, suicide may be viewed as a means of escape, or coping, for older people. This situation may explain the unique pattern of physical illnesses as the primary cause of the majority of older adults' suicides in Hong Kong in recent years.

Given that the spectrum of relative importance of different reasons for suicide in the overall population is shaped by individual profiles of relative importance attributed to age-sex subgroups, suicide prevention strategies should be targeted at specific subgroups as this may also effectively reduce overall suicide rate in the population. In particular, our simulations suggest that due to the projected increase in the proportion of older adults in the Hong Kong population by 2050, physical illnesses may become an even more important driver for the overall burden of suicide as the Hong Kong population ages even further. Our findings suggest that policymakers may need to urgently prioritize the physical and mental wellbeing of older adults. Policy agendas such as 'ageing in place' may need to be implemented speedily so as to avoid the tragic scenario of high counts of suicide among the most vulnerable citizens of Hong Kong's future society. The trends and suicide projections in Hong Kong presented in this paper may serve as a reminder for relevant stakeholders in similarly-aging East Asian societies like Japan and South Korea to take early precautionary steps in preventing similar scenarios.

The institution of the Chinese family also warrants attention. In all age groups, family issues were common reasons for suicide, indicating that family relationships may unfortunately be a frequent source of stress and anxiety. From a population health perspective, there should thus be a concerted effort in policymaking to emphasize the importance of the family as a protective factor against suicide, such as promoting flexible working arrangements to allow parents to spend time with their children and foster filial bonds. How families function, and how this mitigates suicide risk cannot be underestimated, especially in Chinese culture.[42]

This study has several limitations. First, to estimate the RSC network, the simulation assumes that reasons for suicide and the suicide rate do not change significantly over time. This assumption has been valid in Hong Kong since 2011 when the age-standardized suicide rate was at 9–10 percent. Over time, however, this assumption might not hold, and the simulation might not be meaningful. For example, even in the past few years, numerous studies have concluded that the coronavirus pandemic has had a negative impact on population mental health, including worsening psychological distress and possibly increases in suicidal behaviors,[43,44] demonstrating how quickly suicide rates can change over time. Second, there were over 4500 suicide cases (25.90%) in which the Coroner's Court could not conclude the reasons for suicide, possibly due to inconclusive evidence, making it inappropriate to use these records to model for reasons for suicide through imputation. Though the true reasons for suicide can never be accurately determined, the RSC network provides a new perspective to understand the temporal and life-cycle change in suicide.

In conclusion, using the RSC network enabled us to incorporate multifaceted reasons for suicide, to elucidate relative importance of reasons in different sex-age groups. The proposed co-occurrence network approach shows agreement with the extant literature on different suicide reasons' variations across age groups, sexes, and time, and provides a valuable tool for visualizing how reasons for suicide eigencentrality interact with changes in the future Hong Kong population structure. Furthermore, the RSC network simulation provides an informative, innovative 'what-if' analysis tool for policymakers and researchers to understand the potential impact of possible scenarios (as can be modelled by customizing co-occurrence and population structure matrices) on suicide incidence and prevalence in a target population. If policymakers and researchers took a population health approach towards suicide prevention by incorporating network analysis in decision-making, it would have local and worldwide benefits.

Contributors

Y.C.H., A.J., and P.S.F.Y. formulated the research question. C.W. and T.M.L. contributed to data preparation and pre-processing. Y.C.H., A.J., C.W., and Q.Z. contributed to the analysis and methodology. Y.C.H., F.C., J.L., and P.S.F.Y. facilitated discussions of the research findings. Y.C.H., A.J., I.D.L., and P.S.F.Y. wrote and reviewed the manuscript. All authors have read and agreed to the final version of the manuscript.

Data sharing statement

The data and code for the simulation study are available at https://github.com/YuChengHSU/cc_report.

Declaration of interests

The authors declare that there is no conflict of interest.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2023.100752.

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