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**Suicide clusters in Australian youth: A nationwide study
of risk factors and cluster prevention**

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This thesis is being submitted in total fulfilment of the degree Doctor of Philosophy

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Abstract

Background: Young people have been shown to be two to three times more likely than adults to be involved in a suicide cluster. Yet, despite significant public health investment in the detection and prevention of suicide clusters, there is currently no gold-standard definition of what constitutes a suicide cluster, resulting in significant heterogeneity in way that suicide clusters are operationalised and detected. Further, few studies have examined how these differences influence our understanding of the characteristics, risk factors, and mechanisms underlying different suicide clusters. These gaps in evidence present a missed opportunity for the development of more precisely targeted interventions that aim to avert further suicides during an emerging suicide cluster.

Aims and objectives: The broad aim of this thesis was to investigate the different definitions, risk factors, and mechanisms underlying suicide clusters to improve the precision with which communities respond to this public health burden. Specifically this thesis aimed to: 1) identify and compare the characteristics and definitions of suicide clusters using three common definitions of suicide clusters; 2) identify whether social links between cluster members can be identified using nationwide data; 3) quantify the association between exposure to suicide and exposure to suicide attempt on the independent outcomes of suicidal ideation, suicide attempt and suicide death; 4) identify the mechanisms underlying clusters that involve social links between cluster members based on two competing theories, namely the social transmission of suicidal behaviour and assortative relating.

Methods: This thesis comprises three empirical studies that address each of the aims above. Study one (**Chapter 2**) involved a study of suicide clusters in 3027 Australians, aged 10-24, using data from the National Coronial Information System (NCIS). Suicide clusters were identified using: 1) the scan statistic; 2) a systematic search of coronial inquests into suicide clusters; and 3) descriptive network analysis. These techniques were chosen to operationalise three common definitions of suicide clusters, namely those which are greater than statistically expected, those which are perceived as significant, and those which involve social links between cluster members. Study two (**Chapter 3**) involved a systematic review and multi-level meta-analysis to examine the independent association between exposure to suicide and exposure to suicide attempt on outcomes relating to suicidal ideation, suicide attempt, and suicide. Study three (**Chapter 4**) examined the mechanisms underlying suicide clusters characterised by social links between cluster members. Individual-level risk factors were identified by examining the free text of police, coroner, autopsy and toxicology reports for the 3027 suicides included in **Chapter 2**. Evidence of the social transmission of suicidal behaviour (i.e., suicide contagion) and assortative relating were identified by examining the casewise concordance of the demographic, social, and clinical risk factors, as well as the circumstances of death among index and exposed cases involved in a suicide cluster. Lastly time-to-event analysis was conducted to identify the period of risk following exposure to suicide.

Main results: **Chapter 2** showed that the same data, when analysed in different ways identified markedly different point clusters. This was demonstrated by the significant differences in the location, size, duration of point clusters identified by the three common, yet methodologically different, cluster detection techniques. In doing so, the

study showed that different methods for determining suicide clusters may have different implications regarding the scale of intervention that can be implemented. **Chapter 3** showed that exposure to suicide is associated with subsequent suicide and suicide attempt, but exposure to suicide attempt is associated with suicide attempt only. From a suicide cluster perspective, results from the systematic review and meta-analysis suggest that exposure to suicide and suicide attempt do not incur uniform risk across the range of suicide, suicide attempt and suicidal ideation outcomes. The findings provide key insights into the potential risk factors associated with suicide clusters and pave the way for future studies involving the potential clustering of suicide attempt and/or self-harm behaviour. **Chapter 4** showed young people who were exposed to suicide and were involved in a suicide cluster did not cluster on the basis of pre-existing clinical risk factors. However social factors such as residential remoteness and Aboriginal and Torres Strait Islander background were common risk factors among index and exposed cases. Additionally, young people who were exposed to the suicide of another were more likely to share similar circumstances of death, such as the method of suicide used. Results from the survival analysis shed light on the critical period of risk among young people who were exposed to the suicide of another and involved in a point cluster. These findings showed that the first three months (90 days) following exposure to the suicide of a friend or peer represents a period of heightened susceptibility to point clusters, which has important implications for preventative strategies.

Discussion and conclusion: The findings reported in this thesis challenge the one-size-fits all approach to the detection and prevention of suicide clusters, and instead suggest that different suicide clusters may be associated with different characteristics, risk factors and mechanisms.

It revealed important methodological factors that may influence our understanding of the characteristics and mechanisms of point clusters and provided insights into the use of diverse inferential techniques to overcome some of the methodological challenges that exist in cluster research and the field of suicide prevention research, more generally. These findings pave the way for the development of more targeted interventions for the detection and response to suicide clusters in the community.

Declaration

This is to certify that

This thesis comprises original work conducted by me towards the award of Doctor of Philosophy;

due acknowledgement has been made in the text to account for all other material used;
and

the thesis is fewer than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

Nicole T.M Hill, 2 September 2020

Preface

This thesis comprises three manuscripts presented as separate chapters. I was the lead author on all three manuscripts that form the basis of the thesis. Each study was conducted in collaboration with colleagues in Australia and internationally. All references included in the original published manuscripts have been reformatted to suit the style of this thesis. A summary of each empirical chapter of the thesis and the contribution of each co-author is described below.

Chapter 1 introduces the topic of suicide clusters in young people. Information included in this chapter is original, however some of the content was published during my candidature as a commissioned review on suicide clusters in children and adolescents in the journal *The Lancet Child and Adolescent Health* on October 09, 2020 (Impact Factor: 8.54). This manuscript involved a collaboration between international experts in the field of suicide clusters. I was responsible for conducting the literature search, screening of eligible articles and data-extraction. I wrote the initial draft, conceptualised and created all the figures and tables included in the manuscript and circulated the manuscript to co-authors who edited their topic area based on their expertise and experience. A copy of the manuscript is included in appendix 1.

Chapter 2 investigates the outcomes associated with different definitions of suicide clusters using three different cluster detection techniques, namely the scan statistic, a systematic search of Australian coronial inquests into suicide clusters, and descriptive network analysis of young people who, prior to their suicide, shared social links. These methods were chosen to operationalise suicide clusters which are statistically significant, perceived to be significant by communities, and those which involve social

links between cluster members. Data from this study includes 3027 Australian young people who died by suicide in 2006-2015 recorded in the Australian National Coronial Information System (NCIS). The manuscript was published in the journal *Epidemiology and Psychiatric Sciences* on 6 August 2020 (Impact Factor: 6.408) and is available in appendix 2. I was responsible for all aspects of the study including the study conceptualisation, data curation, methodology, formal analysis, writing, reviewing and editing. Details of each author's contribution are detailed below.

Conceptualization: Nicole T.M Hill

Data curation: Nicole T.M Hill

Methodology: Nicole T.M Hill, Lay San (Tiffany) Too,

Formal analysis: Nicole T.M Hill

Writing: Nicole T.M Hill, Lay San (Tiffany) Too, Jo Robinson,
Matthew Spittal

Reviewing and editing: Nicole T.M Hill, Jo Robinson

Chapter 3 is the first systematic review to utilise multi-level meta-analysis to quantify the independent association between exposure to suicide and exposure to suicide attempt on suicidal ideation, suicide attempt and suicide outcomes. The manuscript was published as an open access article in the journal *Plos Medicine* on 31 March 2020 (Impact Factor: 11.05) and is available in appendix 3. I was responsible for all aspects of the study including the study conceptualisation, data curation, methodology, formal

analysis, writing, reviewing and editing. Details of each authors contribution are detailed below.

Conceptualization:	Nicole T.M Hill, Amit Lampit, Allison Milner
Data curation:	Nicole T.M Hill, Karl Andriessen, Alexandra Boland, Alison Clarke, Karolina Krysinska, Amber Payne, Katrina Witt
Methodology:	Nicole T.M Hill, Stephan Krohn, Amit Lampit
Formal analysis:	Nicole T.M Hill, Stephan Krohn, Amit Lampit
Writing:	Nicole T.M Hill, Karl Andriessen, Stephan Krohn, Karolina Krysinska, Amit Lampit, Allison Milner, Jane Pirkis, Jo Robinson, Katrina Witt
Reviewing and editing:	Nicole T.M Hill, Stephan Krohn, Amit Lampit

Chapter 4 investigates the role of two key theories underpinning suicide clusters namely, the social transmission of suicidal behaviour and assortative relating. Data from this study includes 3027 Australian youth who died by suicide in 2006-2015 recorded in the Australian National Coronial Information System (NCIS). The manuscript was published as an open access article in the journal *EClinicalMedicine* on 20 November 2020 and is available in appendix 4. I was responsible for all aspects of the study including the study conceptualisation, data curation, methodology, formal analysis, writing, reviewing and editing. Details of each authors contribution are detailed below.

Conceptualization: Nicole T.M Hill

Data curation: Nicole T.M Hill, Matthew Spittal,

Methodology: Nicole T.M Hill, Matthew Spittal, Jane Pirkis

Formal analysis: Nicole T.M Hill, Matthew Spittal

Writing: Nicole T.M Hill, Matthew Spittal Jane Pirkis, Michelle Tye, Jo
Robinson

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I would like to acknowledge my supervisors A/Prof Jo Robinson, A/Prof Matthew Spittal, Prof. Eóin Killackey and the late A/Prof Allison Milner.

To my Primary supervisor, A/Prof Jo Robinson- I hope this thesis does justice to the incredible support, the wealth of knowledge you have shared, and the many opportunities that you have provided me to help prepare me for a PhD and a career in academia more generally.

I would also like to extend my sincere thanks to Prof. Jane Pirkis, Dr. Tiffany Too for your mentorship as well as A/Prof Sarah Bendall, Dr. Sinn Chong and Dr. Katrina Witt who were instrumental sources of support throughout my candidature. I would also like to express my sincere gratitude to Dr Michelle Torok for providing feedback on this thesis.

This thesis could not have been conducted without the assistance and collaboration of my colleagues Dr. Karl Andriessen, Alexandra Boland, Alison Clarke, Dr. Karolina Krysinksa, Stephan Krohn, Dr. Amit Lampit, and Amber Payne.

At times throughout my candidature I have put my personal life on hold, so to my partner: thank you for giving me the freedom to pursue this goal and for being my rock throughout this process.

I devote this thesis to my mum, Cheryl Lee Condon (October 1960- September 2014). I hope this makes you proud.

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Third Party Copyright Material in Thesis

Citation Information for Third party copyright material	Location of item in thesis	Permission granted Y/N
Hill NTM, Too, LS, Spittal M, Robinson J. Understanding the characteristics and mechanism underlying suicide clusters in Australian youth: a comparison of cluster detection methods. Epidemiology and Psychiatric Sciences. In press, July 2020.	P60-93	N (open-access publication)
Hill NTM, Robinson J, Pirkis J, Andriessen K, Krysinska K, Payne A, et al. Association of suicidal behaviour with exposure to suicide and suicide attempt: A systematic review and multilevel meta-analysis. PLoS Med. 2020;17(3):e1003074-e.	P94-206	N (open-access publication)
Hill NTM, Spittal M, Pirkis J, Torok M, Robinson J. Risk factors associated with suicide clusters in Australian youth: Identifying who is at risk and the mechanisms associated with cluster membership.	P207-235	N (open access publication)

Chapter 1: Background Literature review

1.1 Introduction

Suicide and self-harm (defined as deliberate self-injury, which may or may not include suicide intent) are leading causes of morbidity and mortality, worldwide¹. It is estimated that approximately 800,000 people die by suicide each year¹, of which approximately one quarter are under the age of 25². Due to difficulties in determining suicide intent in children, nationally recorded statistics on youth suicide are typically available from the age of 10 years and above³. However, suicide has been documented in children as young as five⁴⁻⁶. In Australia, suicide is the leading cause of death in young people aged 10-25 years⁷. It is a significant public health burden, accounting for up to 18,744 years of life lost⁷. Between 2008 and 2018, 3,790 young Australians under the age of 25 died by suicide, resulting in an average age-specific rate of 25.8 suicides per 100,000 people^{8, 9}.

Self-harm, including intentional self-harm (otherwise known as suicide attempt) during adolescence is a robust predictor of later death by suicide¹⁰. The most recent hospital admission data in Australia indicates approximately 46,000 young people are admitted to hospital for self-harm each year, resulting in an age standardised rate 187.5 per 100,000 people¹¹. However, these estimates do not include the proportion of young people who present to the hospital for self-harm and leave prior to receiving treatment, are discharged into the community or do not present to healthcare services at all. Self-harm data obtained from self-report measures in the most recent Australian Child and Adolescent Survey of Mental Health and Wellbeing showed approximately 10% of young Australians have self-harmed before the age of 20¹². These findings are

consistent with community estimates of self-harm elsewhere in the world; for example, in the UK which showed approximately 12% of those aged 12 to 17-years self-harmed in the past year¹³.

In Australia and internationally, the incidence of suicide, self-harm, suicide attempt (self-harm with intent to die), and suicidal ideation (thoughts of suicide) increases rapidly during adolescence³, and is up to ten times higher in young people aged 15 years and above compared to those under the age of 14 years¹⁴. Accordingly, the period of adolescence through to early adulthood also corresponds with an increase in the incidence of youth suicide clusters¹⁵.

1.2 Typology of suicide clusters

Three main types of suicide clusters have been identified in the literature¹⁵ and are illustrated in **Figure 1.1** The characteristics of each of these clusters are outlined below.

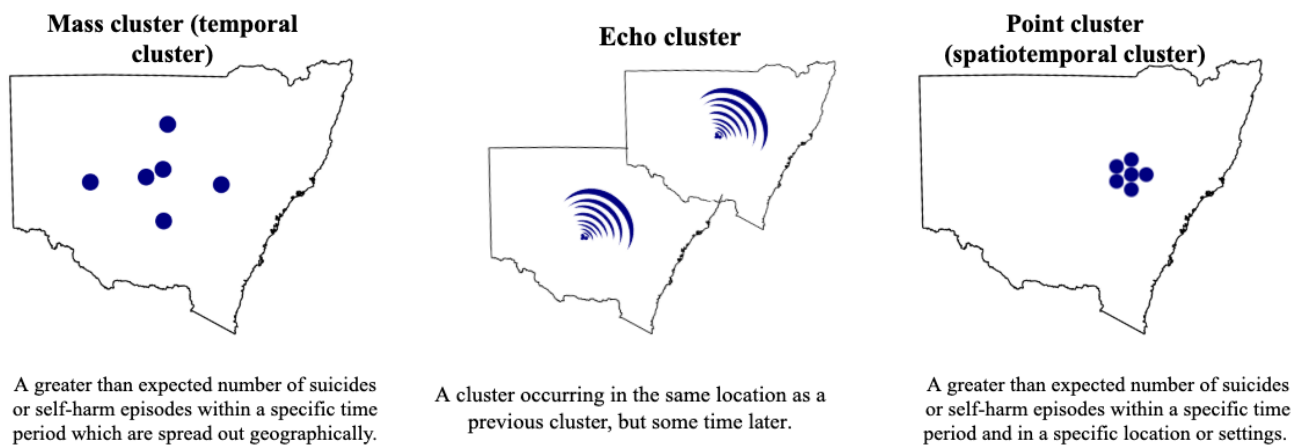


Figure 1.1 Types of suicide clusters

Source: Adapted from Hawton and colleagues¹⁵.

1.2.1 Mass clusters

Mass clusters, also known as temporal clusters, are characterised by a greater than expected number of suicides or suicide attempts, within a short period of time, that are not bound by location or geographic proximity^{15, 16}. Mass clusters typically occur following certain types of media reports— such as those covering the suicide of a prominent public figure¹⁷⁻¹⁸, or following media stories that sensationalise suicide, glorify the deceased, or describe the methods of suicide¹⁹⁻²⁰. For example, a recent meta-analysis found that media coverage of celebrity suicide which included details on suicide method was associated with a 30% increase in suicides by the same method²¹.

Fictional portrayals of suicide in the media have also been linked to an increase in suicidal behaviour²². An analysis of nationwide suicide mortality data in the US showed suicide rates among 10-19-year-olds increased by 13% following the release of the Netflix series '*13 reasons why*' which, over the course of 13 episodes, portrayed the graphic suicide of the 16-year-old protagonist. In this study the increase in suicides occurred during the period in which the series was most popular on social media¹⁸.

In response to the portrayal of suicide in the media and the emergence of mass clusters of suicide, many national and place-based suicide prevention strategies recommend the adoption of guidelines for the responsible reporting of suicide^{23, 24}. These guidelines include ways to reduce the potential for harm that has been associated with certain types of media reporting, including sensationalised language, detailed descriptions of suicide methods, and stories which glorify the deceased²⁵. In contrast, media stories that include messages of hope and recovery following a suicide attempt, as well as content that promotes help-seeking behaviour has been shown to be protective against further suicide and suicide attempts, this is known as the Papageno effect²⁶. Previous studies

have shown that the implementation of responsible media reporting guidelines is associated with improvements in the quality of media coverage of suicide^{27, 28} and a reduction in the incidence of mass clusters²⁹.

1.2.2 Echo Clusters

Echo clusters are a type of suicide cluster that occurs in the same location, but some-time after an initial suicide cluster¹⁵. Echo clusters are a variation of point clusters (see section 1.2.3 below) and are typically bound by both time and space. Empirical studies of echo clusters are limited, particularly in relation to their frequency in young people³⁰⁻³². A nationwide study of suicide clusters in New Zealand found evidence of 10 echo clusters over a seven-year period³², however the characteristics of individual cluster members (e.g., age of the deceased) was not reported. A recent study by Too and colleagues³¹ used the scan statistic (a common inferential method for determining suicide clusters, see section 1.4 '*Methods for determining point clusters*' below) comprising both suicide and hospitalised self-harm in young people aged 15-25 years. However, in this study the predictive validity of index clusters (based on the geographic location of index and echo clusters), was approximately 36%. In other words, the authors found that their method for determining echo clusters resulted in a false positive rate of 64%.

1.2.3 Point clusters

Point clusters, also known as spatiotemporal or space-time clusters are characterised by multiple suicides that occur close together in both space and time; or multiple suicide or self-harm events among individuals who share social links (e.g., peers from the same school/institutional settings, or friends from the same peer group)^{15, 33-36}. Point clusters

have been documented in community settings such as schools, inpatient units, and individual towns and cities¹⁵. However, the advancement of inferential and geospatial techniques has led to the identification of point clusters, which in some instances span multiple states or cities. Further information on the definitions and methods for detecting point clusters are discussed below in section 1.4 '*Methods for detecting point clusters*'.

Point clusters are frequently reported in youth populations¹⁵. The presence of a point cluster is usually the source of significant public concern, particularly in small settings where information about the suicidal act spreads rapidly between individuals within the community. For example, descriptive studies of point clusters in community settings such as schools and local towns or cities have shown that point clusters are associated with widespread speculation about the antecedents and circumstances of the deaths³⁴⁻³⁷, prolonged grief³⁸ and heightened fear and anxiety regarding the prospect of further suicides and self-harm events^{15, 38-39}. Together these factors have been associated with increased incidence of self-harm and the maintenance of suicide clusters within the community¹⁵. In response to the considerable public health impact of point clusters, guidelines to assist community stakeholders with responding to point clusters have been developed in Australia⁴⁰, Ireland⁴¹, New Zealand⁴², UK⁴³⁻⁴⁴ and US⁴⁵ and countries and local communities have developed surveillance systems to detect emerging clusters of suicide and self-harm behaviours⁴⁶⁻⁴⁸.

Despite existing public health efforts targeting point clusters in the community, methodological limitations such as inconsistencies in the definitions and operationalisation of point clusters, ecological biases and the absence of hypothesis driven studies means that, unlike media reporting guidelines for the prevention of mass

clusters, information on how best to respond to point clusters is often based on limited or inconclusive evidence. A consequence is that many stakeholders in the community report feeling ill-equipped to effectively respond to point clusters⁴⁹⁻⁵¹. Given point clusters are a statistically rare (discussed in more detail below in section 1.4 '*Methods for detecting point clusters*') but traumatic event that requires careful management, it is important to understand the characteristics, risk factors and mechanisms underpinning point clusters in order to help communities respond to this phenomenon with better precision. For these reasons, point clusters will be the focus of the present thesis. Further information on the epidemiology and risk factors associated with point clusters are discussed in detail below.

1.3 Definitions of point clusters

A key limitation in advancing the field is that there is currently no gold-standard definition of what constitutes a point cluster³³. Whilst some studies define point clusters on the basis of multiple suicides^{34, 52-54}, others define point clusters as comprising both suicide and self-harm events^{35, 36, 55, 56}. Early studies defined a point cluster on the basis of multiple suicide and/or self-harm events that were linked socially (e.g., friends or acquaintances from the same school, institution other community settings)⁵⁷⁻⁶¹, other studies have defined point clusters on the basis of multiple suicide and/or self-harm events that are greater than statistically expected^{31, 54, 56, 62}. It is unclear whether point clusters that are exclusive to self-harm are equivalent to those which involve suicide. For example, Too and colleagues⁵⁶ found the proportion of self-harm events (defined as hospital admissions for non-fatal suicidal behaviour) that occurred in a self-harm cluster was highest in middle aged adults compared to young people aged 25 years or less. Other studies on self-harm clusters have noted data limitations, such as dependence on

broad area aggregation of postcode data obtained during hospital admissions, which reduces the accuracy of point cluster analysis⁵⁶. Furthermore inconsistencies in the nomenclature used to define self-harm (e.g., non-suicidal self-injury, non-fatal self-harm, and suicide attempt) in hospital admission records means that it is not clear whether studies of point clusters that are characterised by self-harm events represent the same phenomenon, or have the same predictive validity of point clusters that are characterised by suicide events. Given that evidence pertaining to self-harm clusters is significantly limited, the remainder of this thesis will focus specifically on point clusters which involve suicide or a combination of suicide and self-harm events.

Inconsistencies in the way that point clusters are defined is also evident in existing public health guidelines for responding to point clusters. Guidelines in Australia, for example, define a point cluster on the basis of suicide, self-harm, or a combination of both, and note that point clusters may or may not be statistically significant⁴⁰. Whereas guidelines in New Zealand describe point clusters on the basis of multiple suicides which are greater than expected in addition to those which involve social links between suicide decedents⁴². The different definitions of point clusters in existing public health guidelines are shown in **Table 1.1**.

Table 1.1 Definitions of point clusters in existing guidelines for preventing and responding to point clusters.

Resource	Location	Definition
Public Health England, UK. Identifying and responding to suicide clusters: A practice resource.	U.K, 2019	A suicide cluster usually includes three or more deaths; however, two suicides occurring in a specific community or setting (for example a school) in a short time period should also be taken very seriously in terms of possible links and impacts (even if the deaths are apparently unconnected), particularly in the case of young people.
Clinical Advisory Services Aotearoa. Postvention guidelines for the management of suicide clusters.	New Zealand, 2018	Multiple deaths occurring more closely together geographically and in time than would be expected for a given community, or linked by established familial, psychological or social connections.
Centre for Health Policy, Programs and Economics, Melbourne School of Population Health, University of Melbourne. Developing a community plan for preventing and responding to suicide clusters.	Australia, 2012	A suicide cluster can be defined as a group of suicides or acts of deliberate self-harm (or both), that occur closer together in time and space than would normally be expected on the basis of statistical prediction and/or community expectation.
Health Services Executive. Responding to murder and suicide clusters. Guidance document.	Ireland, 2011	Suicide clusters (sometimes referred to as contagion suicides or copycat suicides) involve a number of suicides which may appear to be unrelated, but which occur in a particular area and time, have common method or are in response to defined stimuli.
Centers for Disease Control and Prevention. Recommendations for a community plan for the prevention and containment of suicide clusters.	USA, 1988	Suicide clusters may be defined as a group of suicide or suicide attempts, or both, that occur closer together in time and space than would normally be expected in a given community.

From a public health perspective, the absence of a gold-standard definition of point clusters presents several challenges for communities that are tasked with responding to point clusters. For example, without a consistent definition of point clusters there is no standardised way to statistically analyse point clusters, which in turn limits efforts to

compare and monitor point clusters in the community. Point clusters that are determined on the basis of community expectation can be viewed as inconsistent with the shift towards evidence-based decision-making which has become key priority in national suicide prevention strategies in Australia and internationally^{23, 64-66}. Yet, at the same time, communities may become concerned about a potential suicide cluster, long before sufficient data is available to those responsible for coordinating a response. In Australia for example, suicide deaths require official determination by the state coroner. Together the duration of both the police, medical, autopsy and coronial investigation involves, on average, a two-year process between the incident resulting in death, and official determination of suicide as the cause of death. Given suicide prevention efforts are often resource intensive, it is important that these resources be directed to communities where the need is greatest and that there are reliable procedures in place to minimise the potential misuse of resources (e.g., following unverified or anecdotal reports of suicide clusters). Further, there is a clear gap in evidence that indicates whether existing inferential methods can be used to adequately identify point clusters in small areas or communities, particularly those which have existing suicide prevention teams or local suicide prevention steering committees that are responsible for the coordination of suicide prevention services at a local-level, in the community.

Another limitation is that different definitions of point clusters can be operationalised in different ways, and this may result in the detection of markedly different point clusters which require a different type of response. For example, suicide clusters which involve social links between cluster members may require different screening strategies of high-risk groups compared to point clusters where there are no apparent links between cluster members. Similarly, point clusters which involve both suicide and self-harm events may

require greater resources to appropriately deal with both behaviours, given that both types of suicidal behaviours occur at markedly different rates, and have significantly different public health implications (e.g., self-harm being a measure of morbidity and suicide a measure of mortality).

1.4 Methods for detecting point clusters

Differences in the way that point clusters are defined is associated with how they have been operationalised in the peer-reviewed literature. Previous studies of point clusters can be divided into two broad categories: 1) community-based descriptive studies of suicide clusters; and 2) population-based inferential studies of suicide clusters. These are described in detail below.

1.4.1 Community-based descriptive studies

Early studies of suicide clusters typically involved descriptive case studies in community settings such as a single town or city, high school, inpatient unit, or remote indigenous communities³³. For example, in 1960 Offer and colleagues⁶⁷ described a cluster of self-harm events among adolescents and young adults who were receiving inpatient treatment in the same general hospital. This was followed by a series of case reports documenting self-harm contagion among young people receiving in-patient treatment⁶⁸⁻⁷³ and led to the popular belief that clusters of suicidal behaviour were facilitated by social links between people who were exposed to the suicide or self-harm of others.

In the late 1980s and onwards, descriptive studies documenting the emergence of suicide clusters in schools^{35, 37, 57, 74}, prisons^{75, 76}, and remote communities^{34, 60, 61, 76-78} emerged. These studies described point clusters in terms of multiple suicide deaths that

occurred close in time but in small community settings, some of which involved social links between cluster members. Whilst some of these studies used descriptive methods to compare historical rates of suicide to those that occurred in point clusters^{37, 57}, factors such as the single site location, and small study populations meant that the evidence reported in these studies are generally considered to be of low quality relative to larger population-based studies using inferential techniques such as the scan statistic.

1.4.2 Population-based inferential methods

The last two decades have seen a methodological shift from community-based descriptive studies to population-based studies that use inferential techniques combined with geospatial analysis to identify point clusters using data from suicide and self-harm registries or data collections^{20,31,52,54,56,62}. These studies used statistical methods to determine whether suicides within a particular time and place were statistically greater than expected by chance. In general, these studies were considered to be of a higher methodological quality than community-based studies, as they involved methods that were replicable and therefore more amenable to scientific scrutiny.

One of the most common inferential methods for determining suicide clusters involves the scan statistic^{20, 31, 54, 56, 62, 79-90}. The scan statistic is defined by a cylindrical window with a circular (or elliptic) base representing the area and the cylinder height corresponding to time⁸⁸⁻⁸⁹. A number of probability models are available in the scan statistic, however a Bernoulli, discrete Poisson or space-time permutation model is typically used in studies of suicide and self-harm as this approach is best suited for count data⁸⁹. The Bernoulli, discrete Poisson or space-time permutation model compares the observed number of suicide events to the expected number of suicide events in the population. A point cluster is identified

when the observed number of suicides is statistically greater than the expected number of suicides within a particular place and time.

1.5 The characteristics of point clusters

1.5.1 Case numbers, duration, and spatial parameters

Evidence from community-based descriptive studies of suicide clusters and population-based studies of point clusters using the scan statistic are often treated as synonymous. This has resulted in a significantly heterogeneous body of evidence which has hindered a more precise understanding of the characteristics, risk factors, and mechanisms of suicide clusters, which in turn has limited our capacity to respond effectively. For example, the number of suicides that occur in a single point cluster reported in community-based studies of suicide clusters range between two to 15 suicides. Whereas evidence from population-based studies range between two to 1500 suicides^{33, 54, 85, 90}. Differences in the temporal and spatial parameters between the two methods is also evident. For example, whilst descriptive studies of point clusters range between 24 hours to five years, population-based studies of point clusters typically involve a pre-determined maximum duration of two and a half years and in some instances span multiple towns, states and territories^{54, 86, 90-91}.

1.5.2 Conceptual differences

Whilst population-based studies of point clusters often pre-determine spatial and temporal parameters according to the findings reported in descriptive studies, inherent biases such as small study effects can limit the generalisability of findings reported in community-based descriptive studies. Conceptual limitations are also evident. For example, recent population-based studies of point clusters that are determined by the

scan statistic have suggested that suicides which occur close together in time and space are a proxy measure of social contiguity, reported in previous community-based studies^{54, 62, 79, 85, 90}. Yet, this assumption has not been empirically tested. The extent to which the scan statistic identifies clusters that involve social links between cluster members has important implications for the types of suicide prevention strategies that are implemented in response to a point cluster. However, the ecological design of many population-based studies means that it is currently unclear whether individuals identified in point clusters that are detected using the scan statistic were actually exposed to the suicide of another, either directly or indirectly— with implications for the specific types of prevention or intervention strategies implemented in an area, community, or region.

1.5.3 Frequency of point clusters

Population-based studies of point clusters indicate that young people, under the age of 25 who die by suicide are two to three times more likely to be involved in a suicide cluster, relative to adults in the general population^{54, 80}. Robinson and colleagues⁵⁴ for example, conducted a nationwide study of point clusters in Australia over a two-year period and found that point clusters accounted for 5.6% of suicides in young people under the age of 25 years, compared to 2.3% of adults aged 25 years and above. An earlier study by Gould and colleagues⁸⁰ found evidence of statistically significant point clusters among young people aged 10-24 in a population-based study in the US but found limited evidence of point clusters in adults aged 25 years and above during a seven-year period.

Whilst point clusters have been shown to be more frequent in young people, the proportion of suicides that occur as part of a suicide cluster varies significantly between

studies. A systematic review by Niedzwiedz and colleagues³³ found point clusters accounted for between 1% and 57.5% of youth suicides. Another review by Hawton and colleagues¹³ used evidence from recent population-based studies of point clusters^{54, 80} and concluded that point clusters account for approximately 5.6% of suicides in young people. As noted in the previous sections, differences in the proportion of suicides that occur as part of a point cluster may be associated with *how* a point cluster is operationalised or defined. For example, studies of point clusters that examined the links between cluster members in institutional settings such as high schools have shown that the proportion of suicides (and attempts) that occurred in a cluster to be approximately 9.2%³⁷. However, other studies using large population data on suicide mortality across multiple Australian states and territories have revealed more conservative estimates of point clusters that range between 2.3 to 5.6%^{54, 83, 86}. Another study by Robertson and colleagues⁵², used an inferential analyses of point clusters using the scan statistic and examined the links between cluster members. In doing so the authors found that the proportion of suicides that constituted a point cluster increased from 37.5% to 50%. These findings are important because they suggest that different definitions and methods for determining point clusters may identify markedly different cluster members.

1.6 Risk factors associated with point clusters

1.6.1 Population-level risk factors

1.6.1.1 Sex differences

Many of the risk factors associated with suicides that are part of point clusters are also risk factors associated with non-cluster suicides^{15, 92}. Findings from community-based

studies of point clusters are consistent with the gender paradox reported in studies of suicide and self-harm^{13, 15}. For example, two recent systematic reviews suggested that males are more likely to be involved in point clusters of suicide, whereas females are more likely to be involved in clusters of self-harm^{15, 92}. It is noteworthy, however, that these sex effects have only been reported in community based studies and have not yet been replicated in population-based studies of point clusters^{54, 56, 83}, demonstrating a lack of uniformity in evidence across different studies, populations, and settings.

1.6.1.2 Remoteness and socioeconomic status

Previous population-based studies of point clusters have found an association between residing in a remote location, low socioeconomic status, and an increased incidence of youth point clusters. A nationwide study of suicide and self-harm clusters by Too and colleagues⁵⁶ found people who lived in remote and socioeconomically disadvantaged areas were between seven and 10 times more likely to be involved in a point cluster, relative to those in urban and non-disadvantaged areas. However, it is unclear the extent to which area-level associations - such as remoteness and socio-economic status— are influenced by the characteristics of individuals who reside in those regions or are driven by contextual effects associated with the regions themselves. A study by Agerbo and colleagues⁹³, for example, showed that an individual's sociodemographic status significantly attenuated the association between suicide risk and sociodemographic characteristics that were aggregated at the municipality level.

1.6.1.3 Indigenous origins

Indigenous status has also been associated with membership of a point cluster in Australia and elsewhere. For example, both community and population-based studies of

point clusters in the US and Australia suggest that suicide in young people from Native North American and Aboriginal and Torres Strait Islander populations respectively are more likely to occur as part of a point cluster, relative to the general population^{30, 34, 61, 77, 94-97}. Evidence from two population-based studies of point clusters in Australia, found young people who were of Aboriginal and Torres Strait Island descent were significantly more likely to be involved in a point cluster compared to those who were of non-Aboriginal and Torres Strait Islander descent^{54, 83}. The mechanisms underlying the development of point clusters will be considered in more detail in section 1.7 *The mechanisms underlying point clusters*. However, it is possible that increased rates of point clusters in these populations are linked to the complex interplay between cultural collectivism in close-knit communities, as well as issues related to intergenerational trauma, deprivation, unemployment and reduced health and wellbeing which are more prevalent among Native North American and Aboriginal and Torres Strait Islander populations⁹⁶. Additionally, Indigenous status and socioeconomic status also overlap⁹⁶, meaning that these two things can't easily be distinguished in studies of suicide clusters.

1.6.1.4 Individual-level risk factors

Multiple individual-level risk factors have been implicated in the clustering of suicide in young people. However, as noted above, evidence that distinguishes risk of cluster membership from suicide in the general population is limited. Moreover, the majority of studies reporting individual level risk factors involve community-based descriptive studies of point clusters. A good example is a study by Davidson and colleagues⁵⁷ which found that students involved in a high school point cluster were more likely to have a history of threatened or actual suicide attempt, prior hospitalisation, and mental illness or substance abuse, all of which are also risk factors for suicide more generally.

Another study by Brent and colleagues³⁷ found 75% of students in a combined suicide and self-harm cluster had at least one psychiatric disorder. In this study, psychopathology was responsible for the largest proportionate increase of suicide behaviour, relative to those who were personal friends or acquaintances with the deceased³⁷. Other factors that are associated with cluster membership in young people include pre-existing psychopathology⁷⁰⁻⁷³, substance misuse^{57, 60, 97}, relationship difficulties with family and peers and individuals with a history of physical and sexual abuse⁹⁴⁻⁹⁵. Together, these findings suggest that both exposure to suicide and the presence of adverse life events and pre-existing psychopathology are significant risk factors associated with cluster membership. However these findings have not yet been replicated in population-based studies of suicide clusters.

1.7 The mechanisms underlying point clusters

In the last 60 years there has been little progress made with regards to our understanding of the mechanisms underlying point clusters. Although multiple mechanisms have been put forward to explain the emergence of point clusters, much of what is known about the mechanisms underlying this phenomenon has been inferred from descriptive case studies in the community or studies of suicidal behaviour that fall outside the cluster literature. As such, our understanding of the mechanisms underlying point clusters remains largely theoretical in nature, and somewhat limited.

The mechanisms underlying point clusters can be broadly divided into two theoretical models, namely: 1) those which describe suicide clusters as a result of exposure to suicidal behaviours in others; and 2) those which describe suicide clusters as a result of pre-existing risk factors. The theories relating to each of these models are shown in

Table 1.2. Each of these models and their limitations are discussed in detail below.

Table 1.2 **Mechanisms underlying suicide clusters**

Process	Definition	Key assumption
Model 1: Exposure-based models		
Social learning also known as suicide contagion, imitation or suggestive suicide.	Exposure to suicide creates behavioural cues that are learned and modelled or imitated by individuals exposed to (or have knowledge of) suicidal behaviour.	Exposure to suicide facilitates suicidal behaviour in others.
Cognitive priming	Exposure to suicidal behaviour increases the cognitive availability of preprogramed thoughts in those who are already vulnerable to suicide behaviour.	Exposure to suicide facilitates suicidal behaviour in others.
Complicated bereavement	Exposure to suicide results in significant distress that leads to suicidal behaviour in others.	Exposure to suicide facilitates suicidal behaviour in others.
Descriptive norms	Exposure to suicide facilitates the normalization of suicidal behaviour and increases a person's perception that suicidal behaviour is an acceptable solution.	Exposure to suicide facilitates suicidal behaviour in others.
Model 2: Risk factor-based models		
Assortative relating	Individuals who are vulnerable to suicide may already cluster together based on pre-existing risk factors <i>before</i> exposure to a suicide occurs.	Pre-existing risk factors.
Social cohesion, also known as cultural scripts and social integration	Involves the diffusion of similar ideas and attitudes between-like groups, particularly among highly cohesive cultural identities.	Exposure to suicide facilitates suicidal behaviour in others

1.7.1 Theoretical models involving exposure to suicidal behaviour

1.7.1.1 *Suicide contagion*

Early studies of point clusters described the characteristics of cluster members and found that young people involved in a point cluster were often linked via friends and acquaintances or were peers from the same social circle^{35, 37, 39, 57-61, 73, 98-100}. This led to the frequently cited hypothesis that suicide contagion, also referred to in the literature as suicide suggestion, copycat suicide, and imitative suicidal behaviour, is a key mechanism underlying the development of point clusters^{16, 92}. The term '*suicide*

contagion’ is a concept borrowed from infectious disease models in epidemiology and is used to describe the spread of suicidal behaviour to a vulnerable host following exposure to the suicidal behaviour of another⁹². A systematic review by Haw and colleagues⁹² notes that several components of the infectious disease model can be applied to better understand suicide contagion, including: 1) the concept of host susceptibility (the notion of pre-existing individual vulnerability); 2) modes of transmission (the notion that direct or indirect exposure to suicide may facilitate suicidal behaviour in others); and 3) dose dependency (the notion that frequency of exposure is associated with increased risk). Although the term ‘*suicide contagion*’ is frequently cited (and widely accepted) in the peer-reviewed literature, it has received increasing criticism particularly in the wake of the COVID-19 pandemic (COVID-19 is a respiratory disease caused by a new form of coronavirus). For example, suicide itself is not an infectious disease, and those who are suicidal should not be encouraged to self-isolate from others. Others have noted that the term is associated with misconceptions that elicit fear and stigma^{15, 43, 101}. For these reasons, the term ‘*suicide contagion*’ is increasing being replaced by the more accurate and less stigmatising phrase known as the ‘*social transmission of suicidal behaviour*’^{43, 63, 101}.

1.7.1.2 *Social learning*

Social learning describes the process where people model the behaviour they see in others¹⁰², and is a common theory used to explain both point clusters and mass clusters. Social learning is also described in the suicide cluster literature as suicide suggestion, imitation, or copycat suicide. The term the “Werther effect” is also used. This term is based on Goethe’s 1774 novel, *The Sorrow of Young Werther*, which following its release, was associated with an increase in copycat suicides among men who died by the

same suicide methods and were dressed in similar outfits as the novel's protagonist¹⁰³. Social learning has been used to describe the social transmission of suicidal behaviour via both 'vertical' and 'horizontal' transmission. Vertical transmission is used to explain the association between exposure to the suicide of a popular or revered social figure and subsequent suicidal behaviour in others¹⁰⁴. Instances of vertical transmission of suicidal behaviour have been reported in studies of youth point clusters following sensationalist newspaper reports and following large memorial services which glorified the deceased^{20, 35, 39, 69}.

In contrast, horizontal transmission occurs following exposure to the suicide of a person who the young person perceives themselves to be similar to. An important characteristic of horizontal transmission is the strength of identification between the person who died by suicide and the potential imitator¹⁰⁴ (e.g., young people from similar social or cultural groups). The role of horizontal transmission in the development and maintenance of point clusters has not been empirically investigated, however several studies have shown the clustering of suicide among close friends who shared similar sociodemographic characteristics^{53, 59, 71, 105}.

1.7.1.3 Cognitive priming

Cognitive priming explains the process where exposure to suicide of another increases the pre-existing thoughts of suicide and thereby increases the likelihood that they will act on their suicidal ideation⁹². Cognitive priming has been used to explain suicide clusters that occur in high-risk groups such as young people in inpatient units⁹². Although cognitive priming is a well-documented theory in cognitive psychology¹⁰⁶, there have been no empirical studies investigating the role of cognitive priming in the development and maintenance of point clusters. A recent qualitative study on the

experience of high school students provides some indirect evidence of cognitive priming, however it is unclear how it may be related to the development of the suicide cluster³⁹. In this study, Heffel and colleagues³⁹ found that students who were exposed to a suicide cluster reported increased awareness of suicide. However, these findings are to be expected, and since the study did not indicate whether increased cognitive awareness was associated with increased risk of subsequent suicidal behaviour, the evidence supportive a cognitive priming model in the development of suicide clusters remains limited.

1.7.1.4 Complicated bereavement

Complicated bereavement describes the process where exposure to suicide may either facilitate or exacerbate existing feelings of depression, loss and grief in individuals, which may in turn lead to suicidal behaviour⁹². Symptoms related to grief and distress are frequently reported in/by people bereaved by suicide, including survivors of point clusters, but may be elevated due to the cumulative effects imposed by multiple traumas^{35, 39, 53}. However, given point clusters have been reported following both fictional and non-fictional portrayals of suicide^{15, 107} it is likely that complicated bereavement is a precipitating risk factor, as opposed to a stand-alone mechanism underlying the emergence of point clusters.

1.7.1.5 Descriptive norms

Descriptive norms describe an individual's perception about how common or widespread a particular behaviour is¹⁵. Descriptive norms have not been investigated in the point cluster literature. However, studies in the general population have revealed that young people are more likely to endorse suicidal behaviour as an acceptable option

when they perceive it to be common^{108, 109}. Evidence of a potential dose-effect relationship between exposure to suicide and subsequent suicidal behaviour also supports a descriptive norm hypothesis. A study by Jakobsen and colleagues¹⁰⁹, for example, found that exposure to multiple suicides was associated with a significant increase in a young person's own suicide and suicide attempt. Furthermore, a recent meta-analysis by Andriessen and colleagues¹¹⁰ found some evidence of a dose-response effect. However, reports of the association between multiple suicides has often been reported in the context of subsequent self-harm or suicide attempt outcomes, as opposed to suicide outcomes¹¹⁰.

1.7.1.6 Social integration and social cohesion

Social integration (also known as social cohesion) describes the influence that social structures and expectations have on an individual's behaviour¹⁵. Social cohesion has been described as both a protective and a risk factor for suicide and self-harm behaviours¹¹¹. For example, individuals who are involved in close knit-groups that are characterised by strict cultural expectations may be particularly vulnerable to suicide, particularly when those groups limit an individual's personal identity and behaviours¹¹³. Social cohesion may explain the tendency for point clusters to occur in remote indigenous communities where distress related to a suicide can spread rapidly between dense social networks within the community^{30, 94}.

1.7.1.7 Limitations of exposure to suicide models

Although the association between exposure to suicidal and subsequent suicidal behaviour is a core assumption underlying each of the processes outlined thus far, empirical evidence supporting the fundamental role of exposure to suicidal behaviour

and subsequent suicidal behaviour in others remains mixed. For example, few studies, including systematic reviews, have controlled for the temporal association between exposure to suicidal behaviour and subsequent suicidal behaviour, leaving the causal direction between exposure to suicidal behaviour and subsequent suicidal behaviour unclear^{114, 115}. Furthermore, those studies (of which there are few) which have controlled for the temporal association between exposure and outcome measures have typically been limited to a specific population such as parents and family members^{116, 117}, thus it is unclear whether the association between exposure to suicidal behaviour and subsequent suicidal behaviour in others is generalisable among friends and other acquaintances. Lastly, few studies have determined whether the association between suicidal behaviour and subsequent suicidal behaviour in others is the result of exposure to suicidal ideation, suicide attempt or suicide¹¹⁸⁻¹²². Since each of these exposure and outcomes have markedly different public health implications (suicidal ideation and suicide attempt being a measure of morbidity; and suicide— a measure of mortality) and different rates of exposure, it is not clear whether the association reported in previous studies is inflated by the culmination of multiple exposure and outcome measures. Arguably, the methodological limitations underlying the association between exposure to suicidal behaviour and subsequent suicidal behaviour in others ought to be resolved in order to better understand the emergence of point clusters.

1.8 The theoretical model involving pre-existing risk factors

1.8.1.1 Assortative relating

Assortative relating is an alternate theory to those which involve prior exposure to suicide and is based on the premise that individuals who are vulnerable to suicide may

already cluster together on the basis of pre-existing characteristics (or risk factors) such as adverse mental health or history of self-harm. According to Joiner¹²³, these pre-existing risk factors increase an individual's susceptibility to suicide before the onset of a suicide cluster and that the exposure to a common or shared stressful life event may result in an increase in suicidal behaviour, resulting in a suicide cluster. Previous studies have shown that young people naturally associate with peers that are similar to themselves^{124, 125}. Others have demonstrated that friendships between young people tend to be homophilic (a term that describes the tendency for people to maintain relationships with those who are similar to themselves)⁹² across a range of mental health outcomes related to suicide risk, including depression¹²⁶, aggression¹²⁷ and suicidal ideation¹²⁸.

According to an assortative relating hypothesis, point clusters may emerge in response to simultaneous exposure to external pressures or stressful events (e.g., high rates of unemployment or lack of access to social services) among cluster members¹²³.

Taiminen and Helenius¹⁰⁰, for example, reported a point cluster comprising eight suicides within a psychiatric unit in Finland. In this study, the suicides of two patients in the cluster were unrelated but occurred at a time where there was considerable organisational instability and staff turnover. Another study by Davidson and colleagues⁵⁷ examined the relationship between cluster members in a case control study of two separate point clusters in Texas. Whilst the majority of young people involved in the point clusters shared interpersonal connections, others were not directly acquainted with cluster members. An assortative relating hypothesis appears consistent with previous studies that have indicated that young people involved in point clusters have a range of pre-existing psychopathologies and adverse life stressors^{37, 57, 74, 94}. However, due to methodological limitations, it is not clear from these studies whether the presence

of pre-existing risk factors sufficiently moderate the association between exposure to suicide and subsequent suicidal behaviour among cluster members.

1.8.1.2 Limitations of a pre-existing risk factor model

As with the empirical literature on the social transmission of suicidal behaviour, much of what is known about assortative relating has been reported outside the specific cluster literature. Using data from the National Longitudinal Study of Adolescent Health ('Add Health'), Randall and colleagues¹²⁹ found that exposure to a friend's suicidal behaviour was associated with a significant increase in the likelihood of a subsequent suicide attempt among peers, even after controlling for a range of pre-existing mental health and adverse life stressors. Using the same Add Health data, Abrutyn and Mueller¹³⁰ controlled for family structure, social integration, education attainment and emotional distress and found that exposure to suicide remained a significant moderator of later suicide attempt. Thus, results from the Add Health study suggest that assortative relating alone is unable to explain the association between exposure to suicidal behaviour and suicide attempt. However, it is not clear whether these findings apply to exposure to suicide and subsequent death by suicide, nor whether the same patterns of risk exist in relation to the development of point clusters.

Thus far, only one study has directly compared an assortative relating and suicide contagion hypothesis in the development of point clusters. Using agent-based simulations, a method based on computational models of theoretical suicidal behaviour, Masoudi¹³¹ demonstrated that the social transmission of suicidal behaviour (i.e., social learning), accounted for a greater proportion of point clusters compared to those associated with assortative relating. In this study social learning accounted for approximately 20% to 80% of point clusters compared to 10% to 20% of point clusters

attributed to assortative relating. However, the findings reported by Masoudi were based on simulated data, thus no direct tests of these two hypotheses have been conducted using empirical studies. To date, no further studies have distinguished between the potential mechanisms underlying point clusters. Rather, it is generally accepted that point clusters operate as a result of multiple mechanisms^{15, 16, 92}. However in order to progress the field towards more targeted interventions and preventative approaches, the core assumptions underlying these mechanisms must first be addressed. Understanding which mechanism is operating in a suicide cluster has the potential to inform how communities would be best placed to respond to suicide clusters with better precision.

1.9 Responding to point clusters

1.9.1 Empirical evidence

It is generally acknowledged that a systems approach (defined as evidence-based interventions from population level to the individual, implemented simultaneously within a particular community)^{132,133} or multilevel interventions are required to respond to point clusters in the community and avert further suicides and self-harm events^{39, 133-134}. Previous studies have shown that community-based public health programs involving universal interventions (targeting the general population), selective interventions (targeting at-risk groups) and indicated interventions (targeting high-risk individuals) can effectively reduce rates of suicide within the community^{135, 136}.

However, empirical evidence documenting what works when responding specifically to suicide clusters in the community is limited. A recent study by Lai and colleagues¹³² investigated the effectiveness of a multi-strategy community-based cluster response intervention in response to a suicide cluster in Hong Kong using cluster response

guidelines developed by the Centre for Disease Control (CDC) in the US⁴⁵ (the core components of existing cluster response guidelines are shown in **Table 1.3** below). In this study the authors concluded that the community-based program was associated with increased mental health awareness, the mobilisation of community resources, and collaboration between community stakeholders. However, it is unclear whether a reduction of suicide rates was observed nor is it clear whether there were improvements in proximal risks such as complicated grief and help-seeking behaviours among those who were directly affected. Furthermore, it was not possible to determine whether the observed effects were influenced by a single intervention or the interaction between multiple interventions—a common challenge experienced in the evaluation of complex interventions¹³⁷.

A systematic review by Cox and colleagues¹³⁸ identified one out of six studies in the peer-reviewed literature that evaluated the effectiveness of a community's response to a point cluster using longitudinal follow-up data³⁶. In this study, the authors reported findings from a complex intervention in a high school. The intervention comprised: 1) critical incident debriefings; 2) screening of individuals who were high-risk for self-harm, and 3) referrals to students who were identified at high-risk. Although an overall reduction in suicidal behaviours was observed, more recent data has raised questions about the validity of critical incident debriefings, with some studies showing that debriefing interventions are associated with overwhelmingly negative effects such as increased incidence of posttraumatic stress¹³⁹. The effectiveness of screening for individuals at risk has also been called into question, with recent meta-analytic evidence suggesting that screening for suicide risk in high-risk populations is associated with little predictive validity of later suicidal behaviours¹⁴⁰.

Table 1.3 The core components of existing cluster response guidelines

	CASA New Zealand	Centre for Health Policy Programs and Economics Australia	Public Health England	Centers for Disease Control and Prevention USA	Health Services Ireland
1. Preparing for a suicide cluster					
Develop a community cluster response framework outlining the detection, response, and roles and responsibilities for responding to a suicide cluster.	**	**	**	*	*
Establish a multidisciplinary team responsible for responding to a suicide cluster and establishing a lead agency for organising cluster response activities.	***	***	***	*	*
Establish communication agreements between stakeholders and agencies in the community for the detection and response to a suicide cluster.	**	*	*	*	*
Enlist members from local cultural groups in the community to be involved in preparing for a cluster.	***	*			*
Assign a lead agency to oversee and coordinate cluster response activities.	*	*	*	*	*
2. Identifying that a cluster is developing via routine monitoring of suicide deaths and where applicable, media reporting of a suicide death					
Initiate an investigation into a potential suicide cluster using official data sources such as coronial data, emergency department data, and information from agencies and local stakeholders.	**	*	*		
Investigate the characteristics of the suicides, suicide attempts, or self-harm, including method, and psychosocial links between those who have died.	***		**		
3. Media and social media surveillance					
Coordinate with local media for safe reporting of suicide.	***	***	***	*	***
Assign a coordinator or spokesperson responsible for corresponding with the media.	*	*	*	*	*
Enlist local media to publish sources of help and promote recovery in the community.	***				**
Monitoring media and social media for potentially harmful content.	**	*	*		
Utilise social media to promote help-seeking resources.	*	*	***		*
Monitor social media for individuals who may be at risk of suicide.	*	*	**		
Dispel rumours and misinformation about the suicide deaths.	*	*			
4. Education and psychological debriefing					

Announce the suicide privately among family, close friends and those who may be deeply affected.	*	***		*	
Have a plan for announcing the suicide to students and members of the public who may be affected or know someone at risk.	**	*	*		
5. Screening for suicide risk					
Identify family and close friends immediately bereaved and provide screening and referral services for support.	**	*	***	*	*
Enlist members of the community to help identify individuals who may be at risk of suicidal behaviour.	**	*		*	
Identify and screen persons who may be high-risk of suicide.	**	*	***		*
6. Individual, group and community mental wellbeing					
Provide referral to counselling services for those affected.	*	*	*	*	*
Have a plan to scale up access to counselling services.	**	*			*
Establish community support networks for those affected (e.g., via GPs or other local agencies)	**	*	**		*
7. Building community resilience					
Adapt the environment to include means restriction if applicable.	*	*	***	*	
Establish an ongoing surveillance system for suicide and suicide attempt.	*	*	*		
Develop a strategy for improving services or other community level risk factors that contributed to the suicide cluster.	*	**			*
Provide skills and training opportunities in emotional health, wellbeing, and suicide prevention to the public and to service providers and individuals who responded to the suicide cluster.	***	*			
Plan for 12-month anniversaries and other significant events related to the deceased.	***	*	*		
Provide Follow-up screening to high-risk individuals.	*		*		
8. Evaluation					
Provide Debriefing to those who responded to the suicide cluster.	**	*	*		
Review the cluster response activities and update the plan based on what worked or what didn't work	*	*	*		*
Consult with stakeholders and community members about their experience with the cluster response.	*	*	*		*
Debrief stakeholders who responded to the suicide cluster.	*	*	*		*

* The core component is included in the cluster response framework

** The core component is demonstrated in a case study or example scenario to assist with implementation

*** Implementation of the core component is facilitated through the inclusion of templates, worksheets or other practical resource

1.9.2 Gaps in existing guidelines

Methodological limitations such as the lack of adequate collection of baseline data, lack of clarity around which outcome factors should be measured, and the inclusion criteria for the population at risk, makes it difficult to evaluate the effectiveness of cluster response strategies³⁵. This is complicated further by the lack of guiding evidence regarding the characteristics, mechanisms, and risk factors underlying suicide clusters. For example, communities that are tasked with responding to a suicide cluster are often faced with conflicting evidence regarding how long an intervention ought to last, and at what point should the community conduct a long-term evaluation. Consequently, guidelines for responding to suicide clusters continue to draw on findings from studies that report poor quality or outdated evidence.

Another limitation is that existing guidelines for responding to suicide clusters present communities with a one-size-fits all approach that does not currently address the implications which follow from different definitions of point clusters. A case study by Callahan and colleagues³⁵ described a cluster comprising both suicide and self-harm in a high school setting. The initial response to the point cluster included arrangement of student support rooms where students were permitted to visit on their own initiative to receive counselling as well as educational counselling for parents prior to the funeral of one of the deceased³⁵. The authors noted that a subgroup of students who were close with the deceased often attended support counselling in pairs, and frequently discussed the deceased in a glorified and romanticised way which heightened fear and anxiety among the students and parents and corresponded with further suicide attempts³⁵.

Enforcement of individual counselling and mitigation of peer-to-peer reinforcement was

implemented, and these actions resulted in a reduction in suicidal behaviour. Another study by Heffel and colleagues³⁹ conducted qualitative interviews with students affected by a point cluster. In this study many students turned to social media and text messaging to find more information about the student suicides. Students also expressed concern about the lack of memorial services for the deceased which was perceived to interrupt their ability to express grief³⁹. These findings are important because they suggest that suicide clusters which are characterised by social links between cluster members may require a different approach to clusters where there are no clear social links.

1.10 Thesis overview

Developing interventions that can effectively avert further suicides during or immediately following a point cluster is a suicide prevention priority⁴⁰⁻⁴⁵. However, to intervene effectively, the core assumptions that currently shape the field of point cluster research must be held to the same empirical standards as other disciplines within suicide prevention research. The studies included in this thesis were designed to put to test some of the core assumptions in the field of suicide cluster research in order to move the field forward towards a more precise understanding of point clusters.

Because few studies have compared the association between different methods of determining suicide clusters, it is not clear to what extent existing methods detect suicide clusters that are relevant to communities, and how these different approaches influence our understanding of the characteristics of suicide clusters. **Chapter 2** provides the first study to directly compare suicide clusters using the scan statistic, a systematic search of coronial inquests into suicide clusters, and descriptive network analysis to identify social links between cluster members, quantifying the different

characteristics of point clusters described in section 1.5 above according to different methods and definitions of point clusters.

The next chapter, **Chapter 3** examines a leading assumption underlying suicide clusters which are characterised by social links between cluster members, namely, the association between exposure to suicide and suicide attempt on subsequent suicide, suicide attempt and suicidal ideation outcomes. The main purpose of this study was to examine whether an association exists, and whether the association is different according to specific outcome and exposure measures.

Finally, **Chapter 4** tries to address the challenging problem of understanding the specific mechanisms underlying clusters that involve social links between cluster members. A subset of young people who died by suicide, included in **Chapter 3**, were included in a casewise concordance analysis in order to identify whether suicide clusters of this nature are facilitated by imitative suicidal behaviour or assortative relating.

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Chapter 2: Understanding the characteristics and mechanisms underlying suicide clusters in Australian youth: a comparison of cluster detection methods

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Abstract

Background: There is currently no gold-standard definition or method for identifying suicide clusters, resulting in considerable heterogeneity in the types of suicide clusters that are detected. This study sought to identify the characteristics, mechanisms, and parameters of suicide clusters using three cluster detection methods. Specifically, the study aimed to: 1) determine the overlap in suicide clusters among each method; 2) compare the spatial and temporal parameters associated with different suicide clusters; and 3) identify the demographic characteristics and rates of exposure to suicide among cluster and non-cluster members.

Methods: Suicide data were obtained from the National Coronial Information System. N=3027 Australians, aged 10-24 who died by suicide in 2006-2015 were included. Suicide clusters were determined using: 1) Poisson scan statistics; 2) a systematic search of coronial inquests; and 3) descriptive network analysis. These methods were chosen to operationalise

three different definitions of suicide clusters, namely clusters that are: 1) statistically significant; 2) perceived to be significant; and 3) characterised by social links among three or more young people who died by suicide. For each method, the demographic characteristics and rates of exposure to suicide were identified, in addition to the maximum duration of suicide clusters, the geospatial overlap between suicide clusters, and the overlap of individual cluster members.

Results: Eight suicide clusters (69 suicides) were identified from the scan statistic, seven (40 suicides) from coronial inquests; and 11(37 suicides) from the descriptive network analysis. Of the eight clusters detected using the scan statistic, two overlapped with clusters detected using the descriptive network analysis and one with clusters identified from coronial inquests. Of the seven clusters from coronial inquests, four overlapped with clusters from the descriptive network analysis and one with clusters from the scan statistic. Overall, 9.2% (12 suicides) of individuals were identified by more than one method. Prior exposure to suicide was 10.1% (N=7) in clusters from the scan statistic; 32.5% (N=13) in clusters from coronial inquest; and 56.8% (N=21) in clusters from the descriptive network analysis.

Conclusions: Each method identified markedly different suicide clusters. Evidence of social links between cluster members typically involved clusters detected using the descriptive network analysis. However, these data were limited to the availability of information collected as part of the police and coroner investigation. Communities tasked with detecting and responding to suicide clusters may benefit from using the spatial and

temporal parameters revealed in descriptive studies to inform analyses of suicide clusters using inferential methods.

2.1 Introduction

Suicide clusters involve multiple suicides that occur closer in time or place than would normally be expected using statistical inference or community expectation¹. However, multiple suicides that are connected socially are also taken very seriously and are included in recent public health guidelines for responding to suicide clusters²⁻⁴. Young people aged 10-24 years are two to four times more likely to be involved in a suicide cluster, compared to adults in the general population^{5, 6}. Whilst early studies suggest between 1 to 13% of suicides in young people occur as part of a suicide cluster⁵, recent estimates range between 5.2% and 57%⁶⁻⁸. However, these differences appear to depend largely on the type of parameters and methods used to detect suicide clusters.

To date, several high-income countries have implemented surveillance systems for the detection of suicide clusters⁹⁻¹¹ as well as public health guidelines for the response and prevention of suicide clusters in the community^{2-4, 12-14}. Yet, despite significant public health investment, there is currently no gold-standard definition or method for detecting suicide clusters¹⁵. For example, existing public health guidelines define a suicide cluster on the basis of both statistical inference and community expectation and note that suicide clusters may or may not involve social links between cluster members^{2-4, 12-14}.

The absence of a gold-standard definition of suicide clusters has resulted in considerable methodological heterogeneity in the way suicide clusters are operationalised and detected. For example, early studies of suicide clusters described the relationships between suicide those who died by suicide and found that many cluster members shared social links as friends or acquaintances¹⁶⁻²⁰. This led to the common cited hypothesis that suicide contagion, more accurately known as the social transmission of suicidal

behaviour (whereby exposure to suicide facilitates suicidal behaviour in others), is a key mechanism underlying the development of suicide clusters¹.

In the past two decades there has been a methodological shift from descriptive studies of suicide clusters to inferential methods such as Poisson scan statistics. These studies used population data from suicide registries combined with geoinformation systems to determine whether suicides are greater than statistically expected within a particular time and place^{6, 21-23}. Whilst early descriptive studies of suicide clusters were reported in small community settings such as a schools¹⁷, inpatient units²⁴, and remote indigenous communities¹⁸⁻²⁰, the shift towards inferential studies of suicide clusters has established the presence of suicide clusters in large nationwide studies^{5, 6, 21-23, 25, 26}.

Despite being methodologically very different, evidence from both descriptive and inferential studies of suicide clusters are often treated as synonymous. For example, population-based studies of suicide clusters suggest that the close temporal and spatial proximity of suicides within a suicide cluster are a proxy measure of social contiguity among cluster members^{5, 6, 23, 27}. However, the ecological design of these studies means that it is unclear whether individuals were exposed to the suicide of another or shared social links with cluster members. Significant differences in the size and duration of suicide clusters are also evident between methods. Descriptive studies of suicide clusters range between 2 and 11 suicides over a maximum 5-year period¹⁵. In contrast, suicide clusters reported using the scan statistic range between 3 and 1500 suicides over a maximum to 2.5-year period^{6, 8, 23}. In some instances inferential studies have identified suicide clusters that span multiple states and territories^{6, 8, 23}.

Distinguishing between the outcomes of different cluster detection methods has important implications for informing the way that communities detect suicide clusters.

For example, previous studies of suicide clusters using the scan statistic have selected specific spatial and temporal parameters based on the size and duration of clusters reported in descriptive studies^{6, 23}. However, since descriptive studies have typically involved small community settings, it is unclear whether the spatiotemporal parameters used to guide inferential studies of suicide clusters are generalisable to broader populations and settings. Furthermore, distinguishing between suicide clusters which involve exposure to suicide, or links between cluster members, has the potential to improve a community's response to suicide clusters. Arguably, suicide clusters which involve social links between those who died by suicide, may warrant different interventions and preventative approaches compared to those which involve no apparent links between cluster members.

This study sought to identify the characteristics and mechanisms of suicide clusters using three different, but common cluster detection methods, namely, the scan statistic, coronial inquests into suicide clusters, and descriptive network analysis. These methods were chosen in order to operationalise the different definitions of suicide clusters, including those which are statistically significant, those which are significant to communities, and those which involve social links among cluster members. Using the same nationwide data, we aimed to: 1) determine the overlap between suicide clusters for each cluster detection method; 2) compare the spatial and temporal parameters associated with suicide clusters; and 3) identify the demographic characteristics and prior of exposure to suicide among cluster and non-cluster members.

2.2 Methods

2.2.1 Data source and case ascertainment

The study was approved by the Justice Department Human Research Ethics Committee (CF/15/13188). Youth suicides were identified in the National Coronial Information System (NCIS). The NCIS is an online database that records external causes of death in Australia. Each death in the NCIS is accompanied by an individual case number which is linked to a set of core demographic variables including age, sex, indigenous status, employment status, marital status, date of death, and location of death²⁸. Additional data sources in the NCIS include narrative text from police reports, coroner's reports (including inquest findings), autopsy reports, and toxicology findings.

The following cases were included in the analysis: 1) the case was closed and the cause of death was determined as suicide (recorded as intentional self-harm by the coroner); 2) the person was aged between 10 to 24 years at the time of their death, and; 3) the death occurred in Australia between 1 January 2006 and 31 December 2015 (N=3365). The year 2015 was selected as the study endpoint because over 90% of suicides from this time period were closed and therefore fully investigated by the coroner²⁹. A case was excluded if: 1) the death occurred outside Australia; 2) the cause of death was undetermined; or 3) the case did not include at least one coroner or narrative police report (N=93). Finally, suicides which occurred in the state of South Australia (N=245) were excluded due to the limited availability of narrative texts in police and coroner reports. As a result, a total of 3027 cases were included in the analyses. Due to the sensitivity of these data and ethics agreement with the NCIS it was not possible to

obtain information on the number of cases that were probable suicides with undetermined intent.

2.2.2 Methods for detecting suicide clusters

2.2.2.1 The scan statistic

The scan statistic was used to identify suicide clusters that were statistically significant using inferential methods. The space-time scan statistic was used to identify the presence of spatiotemporal suicide clusters in Australia using the software SaTScan version 9.4.4³⁰. Each suicide was acquired at the individual level and aggregated by the month of death and SA2. The 2011 Australian standard population (the midpoint of our study period) was used to estimate age-adjusted rates of suicide in young people aged 10 to 24 years. Population estimates were recorded for each SA2 from the 2011 Estimated Resident Population recorded by the Australian Bureau of Statistics (ABS).

The Poisson discrete scan statistic was used to detect high relative rates of suicide incidence and was conducted separately in each state and territory. The likelihood of each possible cluster was assessed using Monte Carlo simulations²³. Consistent with previous studies⁶, the minimum time window was set at seven days to a maximum of 730 days (two years) and the maximum spatial window at 10% of the population at risk with a maximum radius of 100km²⁶. This resulted in a set of cylindrical scanning windows where the base represents the area of the suicide cluster and the height represents the duration of the cluster²⁶. Clusters were included if their p value was less than 0.10 to account for the statistically rare incidence of suicides³¹. Clusters are referred to as ‘possible clusters’ in the $0.10 < p < 0.05$ range and ‘clusters’ if $p < 0.05$.

2.2.2.2 *Coroner inquests into suicide clusters*

Coroner inquests into suicide clusters were used to identify suicide clusters that were perceived to be significant by communities that had experienced multiple suicides. A custom query was built to identify all cases where the cause of death was intentional self-harm and the term ‘cluster’ or ‘contagion’ was included in the coroner reports. No limitations were placed on the distance or duration between suicides included in a coronial inquest. A case was identified as a cluster member if it was included in a coronial inquest into a suicide cluster in Australia during the study period. A case was excluded if: 1) the term ‘cluster’ did not refer to a cluster of suicidal behaviour (e.g., “cluster B personality traits”); or 2) the suicide did not meet the eligibility criteria for included cases in the NCIS outlined above. A total of 55 case records were identified in the initial search and were manually inspected by the first author (NTMH) for cluster membership. A total of seven independent coronial inquests into suicide clusters were identified, encompassing 40 individuals who died by suicide. Further details on the case ascertainment of cluster members is provided in **Text S1 Methods** in the supplement.

2.2.2.3 *Descriptive network analysis*

Descriptive network analysis was used to identify suicide clusters that comprised social links between three or more young people who died by suicide^{4, 32}. The narrative text from police and coroner’s reports was examined for evidence of social links between young people who died by suicide. Cases were linked if: 1) the young person was known to have been exposed to the suicide of another young person (e.g., they knew a friend who died by suicide; or they knew a peer from their school who died by suicide); 2) the police or coroner report referred to the first and last name of the person who previously died by suicide (the index case); 3) the police or coroner report referred to

the date of death (e.g., month and year) and described at least one other characteristic that could identify the index case based on information included in the case records (e.g., the name of the school); and 4) There was evidence of social links between at least three or more individuals who died by suicide. No limitations were placed on the distance or duration between linked cases. A case was not linked and included in the network analysis if: 1) the police or coroner's report did not provide sufficient information on the index suicide death(s) or did not sufficiently match an eligible case in the NCIS; or 3) The suicide did not meet the eligibility criteria for included cases in the NCIS outlined above. Further details on the case ascertainment of linked cases is provided in **Text S1 Methods** in the supplement.

2.2.3 Comparison of cluster detection methods

Cluster membership was analysed as a binary variable representing the presence or absence of the outcome (cluster and non-cluster membership). Location of death was based on Statistical Area Level 2 (SA2) recorded in the NCIS. SA2s are general-purpose areas which represent communities that interact socially and economically³³. They represent a population range of 3,000 to 25,000 persons and have an average population of approximately 10,000 persons³³.

The comparison of cluster detection methods included: 1) the duration of the suicide cluster (the period of time between the index and last suicide death in the cluster); 2) the proportion of geospatial overlap between cluster detection methods (e.g., the number of suicide clusters that were detected by more than one method); 3) the spatial congruence between overlapping clusters (e.g., the proportion of SA2 spatial units that were identified within overlapping clusters); and 4) the number of overlapping cluster

members (e.g., the number of individual cluster members that were identified by more than one cluster method).

The characteristics of cluster members was identified using the core demographic variables in the NCIS (age, sex, indigenous status, employment status, date of death, location, and manner of death). Evidence of prior exposure to suicide was recorded for each case based on information recorded in the police and/or coroner's reports (e.g., family history of suicide or the death of a friend, peer or colleague). Differences between cluster and non-cluster members were compared using Pearson's chi-square test of independence. Fisher's exact test was used when more than 20% of cells had expected counts less than five. All analyses, with the exception of the scan statistic, were conducted using R version 3.6.2. The geocode function of the ggmap package was used to identify the geocoordinates of each SA2 and to visualise the location of suicide clusters for each cluster detection method.

2.3 Results

2.3.1 Characteristics of suicide clusters

The scan statistic. Eight spatial-temporal clusters of high relative risk were detected in six Australian states and territories (**Figure 2.1**). A total of 69 young people were identified as cluster members, accounting for 2.3% of suicides. The number of individual's involved in a single suicide cluster ranged between 3-20 and the duration of each suicide cluster ranged between 6-725 days (**Table 2.1**). Cluster members were more likely than non-cluster members to be from Aboriginal and Torres Strait Islander origins and to reside in a remote or very remote location. Evidence of prior exposure to suicide was reported among 10.1% (7/69) of cluster members compared to 6.6 %

(195/2958) of non-cluster members but this difference was non-significant ($p=0.38$).

The remaining demographic characteristics were comparable among cluster and non-cluster members (**Table S2.5**).

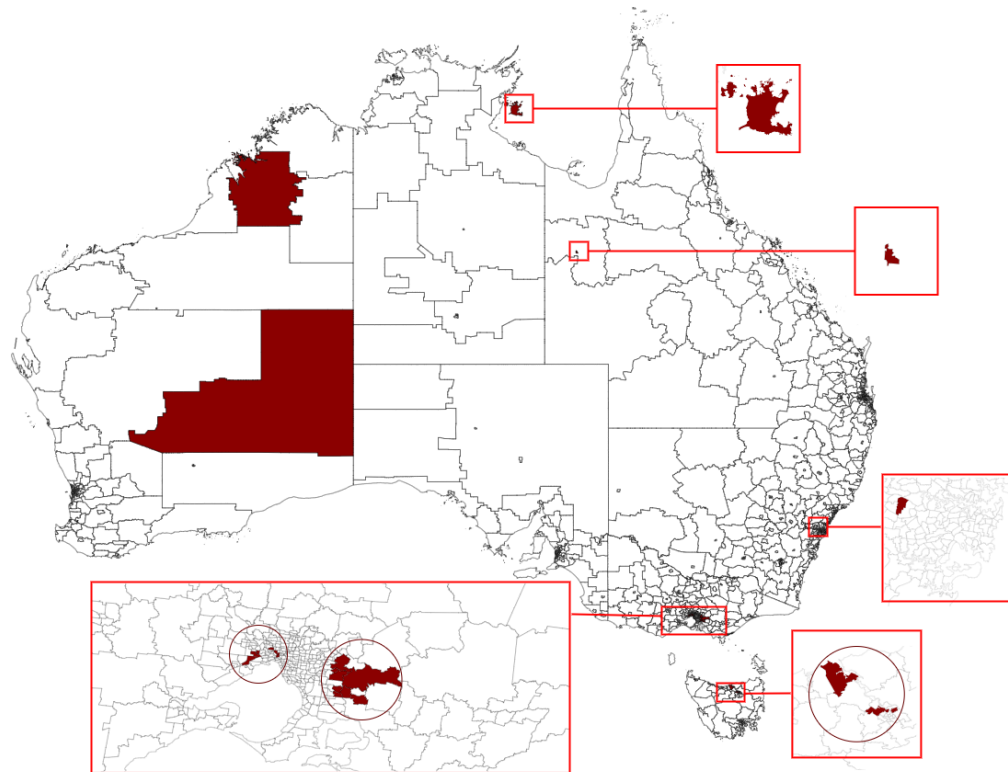


Figure 2.1.1 Geographical locations of suicide clusters identified in Australian youth in 2006-2015 using the scan statistic. Geographic regions are based on Statistical Area 2 geographies (red). The circles represent a group of SA2s involved in a single cluster. All suicide clusters that were detected using the scan statistic were limited to a 100km radius but are visualised using entire SA2 boundaries.

Table 2.1 Characteristics of suicide clusters detected using the scan statistic, coronial inquests, and descriptive network analysis of contagion linked clusters

Cluster location	Year	Cluster duration N (days)	SA2 areas ^a N	Observed cases N	Exposed to suicide N (%)	Geographic overlap ^b	Spatial congruence ^c N (%)	Overlapping persons ^d N (%)	Geographic overlap ^b	Spatial congruence ^c N (%)	Overlapping persons ^d N (%)
A. The scan statistic						Comparison A-B			Comparison A-C		
New South Wales	2013	125	1	6	1 (16.7)	None	.	.	None	.	.
Northern Territory	2013	6	1	3	1 (33.3)	None	.	.	None	.	.
Queensland	2014	713	1	10	1 (10)	None	.	.	None	.	.
Tasmania	2010-2012	62	4	5	0 (0)	None	.	.	None	.	.
Victoria	2015	314	8	20	2 (10)	Partial	2 (25)	2 (10)	Partial	3 (37.5)	3 (15)
Victoria	2011-2012	62	7	10	2 (20)	None	.	.	None	.	.
Western Australia	2011-2013	725	1	12	0 (0)	None	.	.	None	.	.
Western Australia	2015	10	1	3	0 (0)	None	.	.	None	.	.
Total		252.13 (304.1) ^e	24	69	7 (10.1)		2 (8)	2 (3)		3 (12.5)	3 (4.3)
B. Coronial inquests						Comparison B-C			Comparison B-A		
Queensland	2007-2008	387	4	4	2 (50)	Partial	3 (75)	3 (75)	None	.	.
Queensland	2014-2014	121	3	3	3 (100)	None	.	.	None	.	.
Victoria	2009	224	3	5	2 (40)	Partial	1 (33)	3 (60)	None	.	.
Victoria	2011-2012	446	8	8	2 (25)	Partial	4 (50)	4 (50)	partial	2 (25)	2 (25)
Western Australia	2006-2007	433	2	6	0 (0)	None	.	.	None	.	.
Western Australia	2008-2009	374	2	4	1 (25)	None	.	.	None	.	.
Western Australia	2012-2015	914	3	10	3 (30)	None	.	.	None	.	.
Total		414.14 (250.2) ^e	25	40	13 (32.5)		8 (32)	10 (25)		2 (8)	2 (5.0)
C. Descriptive network analysis						Comparison C-B			Comparison C-A		
New South Wales	2008-2010	549	2	3	1 (33.3)	None	.	.	None	.	.
New South Wales	2009-2013	1626	2	3	2 (66.7)	None	.	.	None	.	.

New South Wales	2011-2014	1201	2	4	2 (50)	None	.	.	None	.	.
Northern Territory	2012-2014	767	1	4	1 (25)	None	.	.	None	.	.
Queensland	2008	118	4	4	3 (75)	Partial	3/4 (75)	3/4 (75)	None	.	.
Queensland	2008	219	3	3	1 (33.3)	None	.	.	None	.	.
Queensland	2013	67	2	3	1 (33.3)	None	.	.	None	.	.
Queensland	2015	95	4	4	3 (75)	None	.	.	None	.	.
Victoria	2009	134	1	3	2 (66.7)	Full	1/1 (100)	3/3 (100)	None	.	.
Victoria	2011-2012	226	3	3	2 (66.7)	Partial	2/3 (66)	2/3 (66)	Partial	1 (33)	1 (33)
Victoria	2011	31	3	3	2 (66.7)	Partial	2/3 (66)	2/3 (66)	Partial	1 (33)	1 (33)
Total		457.6 (530.9) ^c	27	37	20 (52.6)		8 (30)	10 (27)		2 (7)	2 (5)

SA2= Australian Statistical Geography Standard- Statistical Area Level 2; SD = Standard deviation.

^aThe number of SA2s (per cluster)

^bComplete (100% overlap among individuals and SA2s) partial (<100 Overlap between cluster members and SA2s); None (no overlap between cluster members and SA2s).

^cThe number and proportion of SA2s that overlap (per cluster)

^dThe number and proportion of individuals that overlap (per cluster)

^eMean (SD)

Coronial inquests. Seven coronial inquests into suicide clusters were detected in three Australian states and territories (**Figure 2.2**). A total of 40 young people were identified as cluster members, accounting for 1.3% of suicides. Six out of seven suicide clusters were described as being greater than expected on the basis of statistical inference and one suicide cluster involved social links between cluster members in an inpatient unit. The number of individuals involved in a single suicide cluster ranged between 3-8 and the duration of each suicide cluster ranged between 121 and 914 days (**Table 2.1**). Cluster members were more likely to be aged 18 years or less (70%, 28/40) compared to non-cluster members (29.7%, 887/2987, $p<0.01$) and were more likely to be from Aboriginal and Torres Strait Island origins (55% vs 14.6% $p<0.01$) and residing in a remote location at the time of death (50% vs 7.20%, $p<0.01$). Evidence of prior exposure to suicide was reported among 32.5% (14/40) of cluster members compared to 6.43 % (192/2990) of non-cluster members and this difference was statistically significant ($p<0.001$). The remaining demographic characteristics were comparable among cluster and non-cluster members (**Table S2.6**).

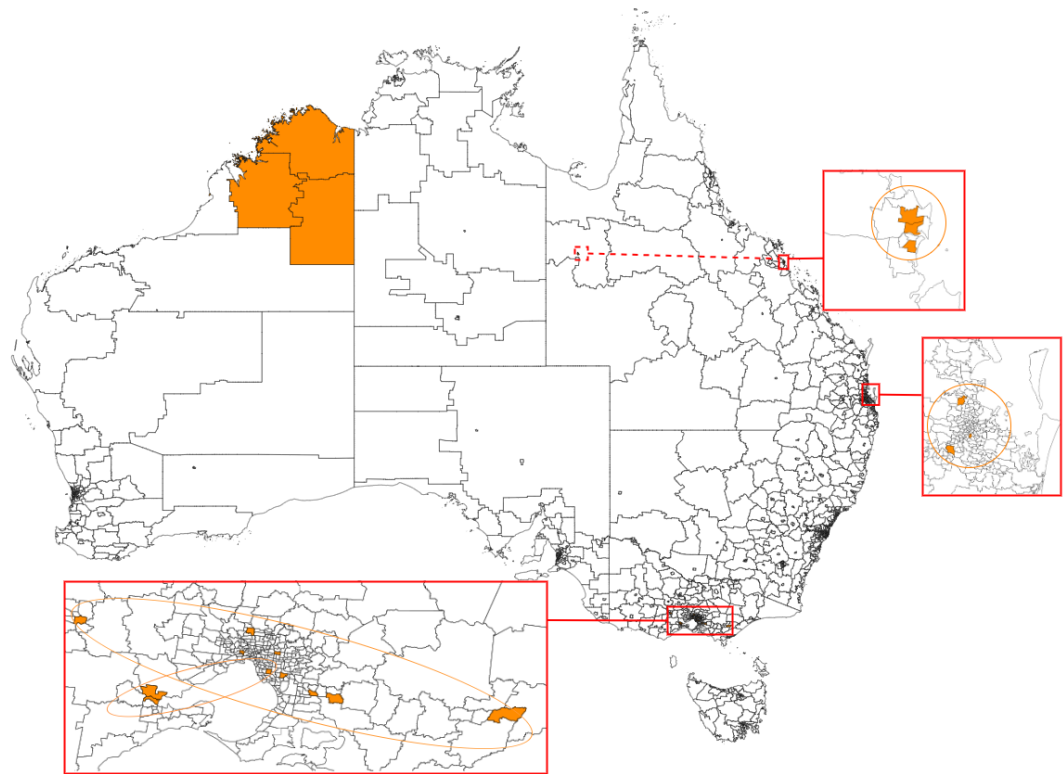


Figure 2.2 Geographical locations of suicide clusters identified in Australian youth in 2006-2015 using information from coronial inquests into suicide clusters. Geographic regions are based on Statistical Area 2 geographies (orange). The circles represent a group of SA2s involved in a single coronial inquest.

Descriptive network analysis. Eleven suicide clusters comprising seven triads and four tetrads were detected in four Australian states and territories (**Figure 2.3**). A total of 37 young people were identified as cluster members, accounting for 1.3% of suicides. The number of individuals involved in a single suicide cluster ranged between 3-4 and the duration of each suicide cluster ranged between 31-1626 days (**Table 2.1**). Cluster members were more likely to be aged 18 years or less (62.2%, 23/37) compared to non-cluster members (29.83%, 892/2990, $p<0.01$). Evidence of prior exposure to suicide was reported among 64.9% (24/37) of cluster members compared to 6.09 % (182/2990) of non-cluster members and this difference was statistically significant ($p<0.001$). The remaining demographic characteristics were comparable among cluster and non-cluster members (**Table S2.7**).

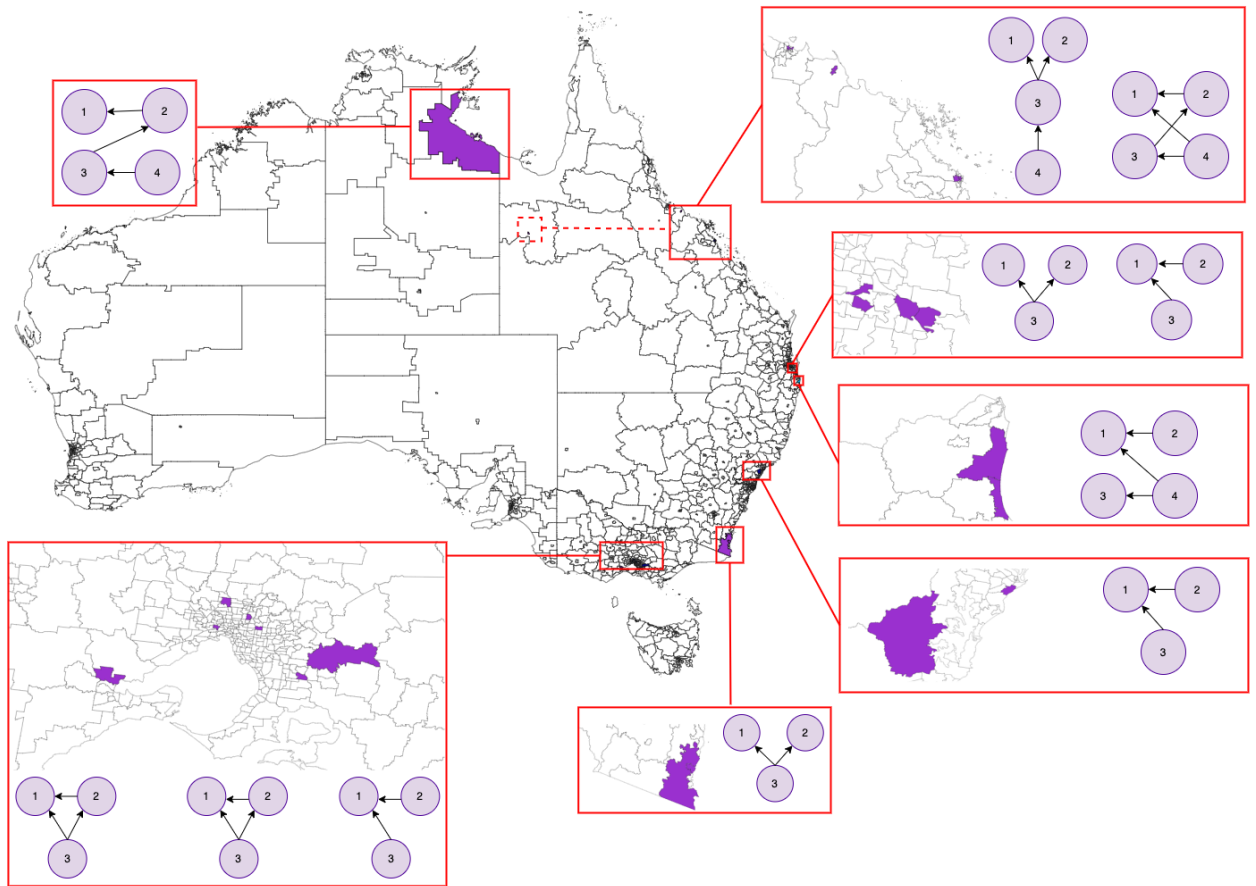


Figure 2.3 Geographical locations of suicide clusters identified in Australian youth in 2006-2015 using descriptive network analysis of social linked suicide clusters.

Geographic regions are based on Statistical Area 2 geographies (purple). The numbered nodes represent the sequence in which the suicide occurred beginning from the index death (1). The arrows represent the direction of exposure to suicide, and the connection between individuals in a suicide cluster.

2.3.2 Comparison of cluster detection methods

Overall, less than 50% of suicide clusters were identified by more than one cluster method (**Table 2.1**). The majority of overlapping clusters involved those that were detected from coronial inquests and the descriptive network analysis (4 out of 8 clusters, **Figure 2.4a-c**). However spatial congruence between overlapping clusters was low (less than 100% of SA2s). The duration of suicide clusters ranged between 6 to 725 days using the scan statistic, 121 to 914 days using information from coronial inquests, and 31 to 1626 days using descriptive network analysis. Overall, one-third (12/133) of cluster members were identified by more than one cluster detection method, however the number of young people that were identified by more than one method ranged from 1 to 3 individuals.

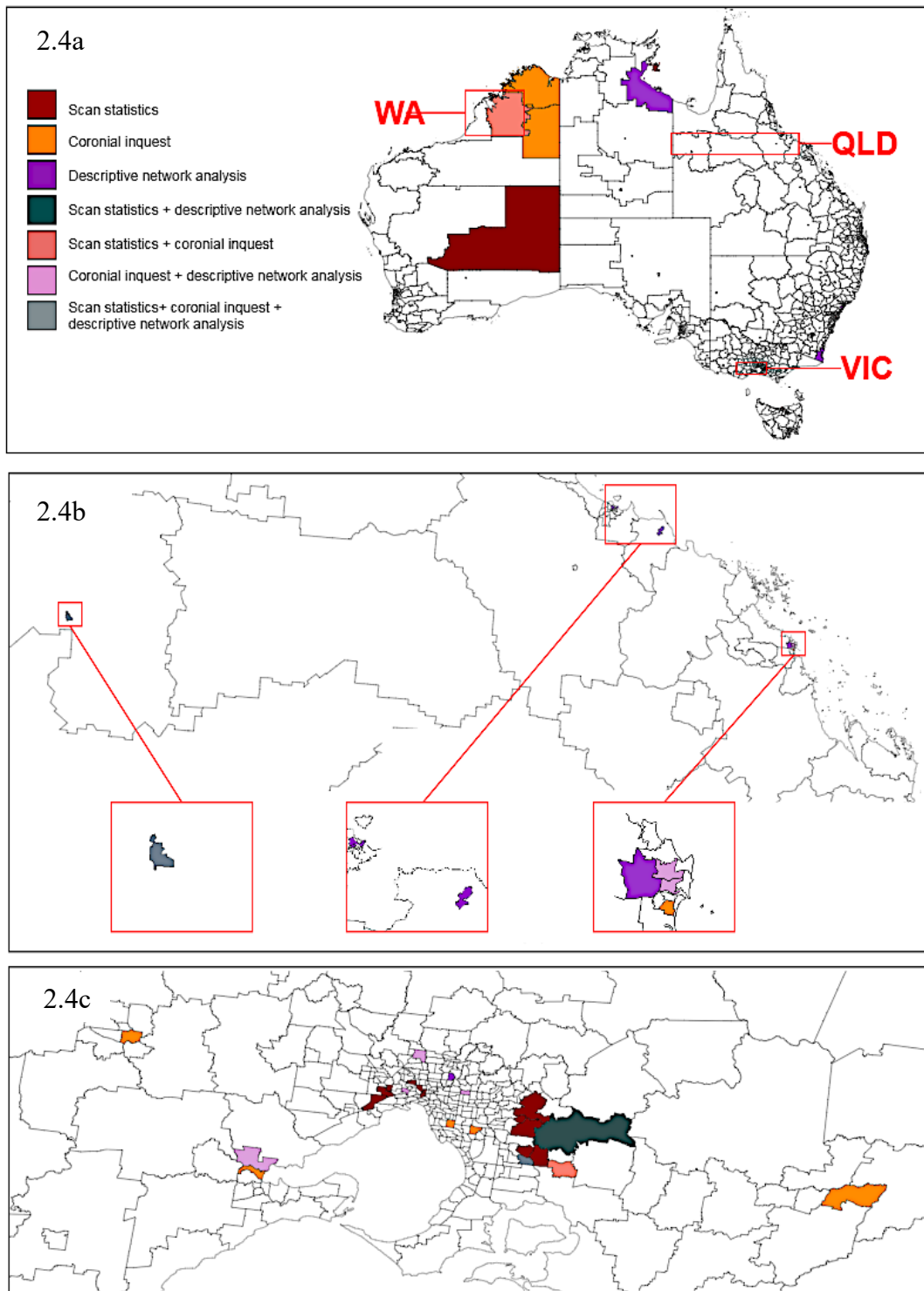


Figure 2.4a-c. 2.4a shows overlapping clusters that occurred across Australia; 2.4b shows overlapping clusters that occurred in smaller regions across Queensland (QLD); 2.4c shows overlapping clusters that occurred smaller regions across Victoria (VIC). All

suicide clusters that were detected using the scan statistic occurred within a 100km radius but are visualised using SA2 boundaries.

2.4 Discussion

This study identified suicide clusters in Australian youth, aged 10-24, who died by suicide in 2006-2015. Comparative analysis of the three cluster detection methods showed considerable heterogeneity in the location, duration, and size of suicide clusters, as well as both the number and demographic characteristics of cluster members. Together these findings demonstrate that the ways in which suicide clusters are defined and operationalised can result in markedly different suicide clusters. This was corroborated by our comparison of cluster members which showed that 90.8% of individuals who were involved in a single suicide cluster were not identified in overlapping clusters, using alternate cluster detection methods.

Although inferential approaches for the detection of suicide clusters have many empirical advantages (e.g., the facilitation of evidence-based decision-making), the accuracy and precision of suicide clusters detected using the scan statistic depends on pre-determined spatial and temporal parameters, for which there is currently no gold-standard. Results from both the coronial inquest into suicide clusters and the descriptive network analysis revealed that the maximum duration of suicide clusters ranged between 2.5-years and 4.5-years, respectively. Together, these findings suggest that the predetermined 2-year parameter used in the scan statistic analyses did not correspond with the maximum duration of suicide clusters that were perceived as significant by local communities, nor suicide clusters which involved social links between cluster members. Since both the coronial inquest into suicide clusters and the

descriptive network analyses were conducted on a nationwide scale and therefore overcome some of the limitations of earlier descriptive studies (e.g., small study effects and limited generalisability) results from the present study have the potential to better inform the parameters used in inferential studies of suicide clusters.

In the present study six out of seven suicide clusters involved in coronial inquests verified by the coroner as being greater than statistically expected. Despite this, there was limited geospatial overlap between coronial inquests and suicide clusters that were identified using the scan statistic. It is likely, that these differences were influenced by broad area aggregation and subsequent differences in the geospatial boundaries used for each method³⁴. Suicide clusters that were detected using the scan statistic, for example, were aggregated by SA2s, however suicide clusters that were detected using coronial inquests did not correspond with precise SA2 boundaries. These findings suggest that spatial parameters comprising broad area aggregations may have limited translational benefit for local communities and stakeholders that are tasked with responding to suicide clusters. The use of point-level geocoded data has been shown to effectively distinguish between the suicide profiles of small community settings and has the potential to overcome spatial biases that arise due to broad area aggregation in studies of suicide clusters³⁵. Future research which investigates relevance of different spatial parameters among stakeholders who are responsible for the coordination of targeted suicide prevention and cluster response activities at the local and regional level is therefore warranted.

Existing guidelines for the detection response and prevention of suicide clusters recommend that community stakeholders use both inferential methods and descriptive methods to identify the links between cluster members. Although the descriptive

network analyses were conducted using nation-wide data, information on prior exposure to suicide was not consistently recorded in the NCIS, resulting in linkage among only 60% of exposed cases. Routine collection of exposure to suicide as part of the police and coroner investigation as well as the inclusion of exposure to suicide in the core-data set of suicide cluster surveillance systems has the potential to improve the sensitivity and specificity of suicide clusters that are characterised by social links between cluster members. Although the findings of the present study suggest that a synthesis of all three approaches for detecting suicide clusters may lead to increased sensitivity and specificity for the detection of cluster members, this approach would be both difficult and time consuming for individual communities that are tasked with responding to a suicide cluster, particularly in the absence of an existing real-time suicide surveillance system in Australia. Future research that examines how best to optimise the detection of suicide clusters using complimentary cluster detection methods in real time, have the potential to advance both the mitigation and prevention of suicide clusters.

Lastly, results from the present study provide some insight into the mechanisms underlying suicide clusters. Lifetime prevalence of exposure to suicide among cluster members that were detected using the scan statistic was 10.1% compared to over one third of cluster members involved in 32.5% of clusters identified through coronial inquests, and 52.6% of cluster members identified using descriptive network analyses.

These findings are contrary to previous studies that suggest that the close spatial and temporal parameters used in the scan statistic is consistent with a social transmission hypothesis^{6, 21, 23, 36}. Whilst the prevention of the social transmission of suicidal behaviour is a core component of existing cluster response guidelines in Australia¹⁴ and

internationally^{2-4, 12, 13}, results from the present study suggest that not all clusters involve social links between cluster members.

2.4.1 Limitations

Although the NCIS is a comprehensive database on coroner determined causes of death, information included in the NCIS is retrospective and may not be immediately available to communities that are experiencing a suicidal crisis— creating a barrier to timely intervention in genuine suicide clusters. Data included in our analysis was dependent on the narrative text of police and coroner's reports. Consequently, information on prior exposure to suicide may not have been recorded if it was not included in the police or coroner investigation, or if informants involved in the investigation did not have knowledge of the young person's exposure to suicide. Further, it is that less than two-thirds of youth suicides identified in coronial inquests has prior exposure to suicide. Although coronial inquests involve an in-depth review of the psychosocial circumstances of death, information collected as part of the coronial enquiry remains subject to the reliability of informant interviews which are prone to factors such as recall bias as well as the lack of knowledge on the subject matter (i.e., whether or not they had knowledge that the deceased had psychosocial connections to another young person who died by suicide). Information on the psychosocial connections between young people who died by suicide may also be confounded by young people who are connected online (e.g., via social media) but was not identified as part of the police or coronial investigation. Previous studies have shown that the digital technology including smartphones, the internet and social media are well-integrated part of young people's lives and transcend traditional boundaries associated with physical and geographic proximity. In this regard, it possible that exposure to suicide via peers within

a young person's online social network were not identified by the information sources used in the current study.

Lastly the limited geospatial congruence between suicide clusters that were detected using the scan statistic are an artefact of the spatial and temporal parameters used in the analysis^{8, 34}, specifically aggregation of suicides using SA2s. Future research should therefore seek to acquire point data in order to detect suicide clusters using inferential methods with greater accuracy and precision.

2.4.2 Conclusions

The present study showed that the same data- when analysed in different ways — may lead to the detection of different suicide clusters. Whilst some suicide clusters involved social links between cluster members, not all cluster members had a history of prior exposure to suicide. The collection of exposure to suicide as part of routine police and coroner investigations has the potential improve the ways communities respond to suicide clusters by distinguishing between suicide clusters that may or may not be driven by social links between cluster members. Finally, results from the present study have the potential to inform the parameters used in inferential studies of suicide clusters, particularly among local suicide prevention teams that are tasked with responding to suicide clusters.

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2.6 Supplementary material

Text S1 Methods

Coronial inquests into suicide clusters

The flowchart of cases involved in coronial inquests into suicide clusters shown in **Figure S2.5**. A total of 56 young people were identified by searching for the police and coroner reports for the term “contagion” or “cluster.” The search was limited to closed cases, involving the suicide of a young person aged 10-24 years, who died in 2006-2015. The custom search identified a total of 58 cases comprising 7 independent clusters. Of these, 18 cases were excluded as false positives due to the description of “cluster B personality” in the police and/or coroner’s report. Excluded cases were therefore identified as non-cluster members in the analyses. The final sample involved 40 cases which comprised 7 independent suicide clusters. Since coronial inquests into suicide clusters were based on the community’s perception of a suicide cluster the definitions and reasons for holding an inquest may potentially differ between each jurisdiction and suicide cluster. The definition and rational for the coronial inquest for each of the 7 suicide clusters is provided in **Table S2.2**

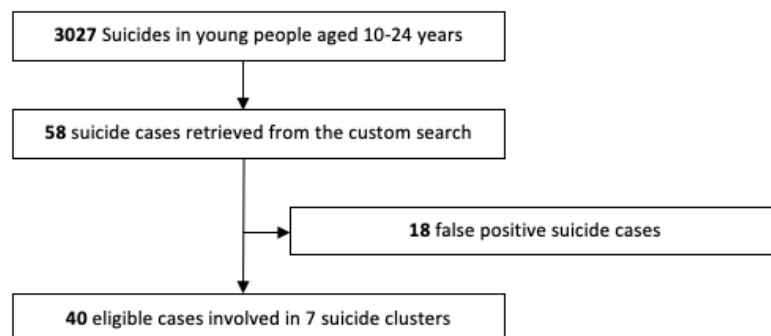


Figure S2.5 Flow chart of included studies in the descriptive network analysis of suicide clusters.

Table S2.2 Definitions of suicide clusters and rationale for the coronial inquest into the suicide cluster

Location	Year	Definition/rationale for inquest into the suicide cluster
Queensland	2007-2008	The community was described as having <i>“experienced an unusually high number of suicides in a small geographical area or institution and over a relatively brief period of time.”</i>
Queensland	2014-2014	Multiple youth suicides in an inpatient treatment unit within a short period of time. It was described <i>“There appears to have been a contagion effect.”</i>
Victoria	2009	It came to the attention of the Coroners Court of Victoria that seven persons aged 18 years and under residing in the region. A retrospective examination of suicides showed that the region had experienced a suicide cluster <i>“as defined by the Centres for Disease Control and Prevention.”</i>
Victoria	2011-2012	A member of the public contacted the Coroners Court of Victoria's Coroners Prevention Unit (CPU) to convey concern about a perceived increased frequency of youth suicide in the City. Statistical analysis revealed the region had experienced an elevated frequency of suspected suicide and <i>“this met the Centres for Disease Control and Prevention's definition of a suicide Cluster.”</i>
Western Australia	2006-2007	The number of youth suicides were described as having <i>“increased 100% during a 12-month period, constituting a suicide cluster.”</i>
Western Australia	2008-2009	The youth suicides in the community were described as <i>“100 times greater than the rate of suicide in the general population.”</i>
Western Australia	2012-2015	The number of youth suicides were described as <i>“significantly higher than expected for the community”</i> during the four-year time period.

Descriptive Network analysis

The flowchart of linked cases is shown in **Figure S2.6** A total of 202 young people who died by suicide had been exposed to the suicide of another during the study period. Of these 120/202 (59.2%) were known to have been exposed to the suicide of another young person and were therefore examined for evidence of links to an unexposed (index) cases. Forty-nine (40/120, 40%) individuals with prior exposure to suicide could not be linked to an index suicide due to insufficient information contained in the police and narrative text in the NCIS. An examination of the core demographic characteristics

recorded in the NCIS indicated no significant differences between linked cases and the 49 cases that were not successfully linked (**Table S2.3**).

We successfully linked 71/120 (59.2%) exposed cases to a total of 46 index suicides, resulting in a total of 117 linked cases. Of the 117 linked cases, a total of 37 cases involved links between at least three or more young people. The remaining 80 cases were excluded because they involved links between two individuals who died by suicide (comprising 40 linked pairs) and therefore not meet our definition of a suicide cluster. The final sample involved 37 linked cases, which comprised a total of 11 suicide clusters (7 triads and 4 tetrads). Overall, 15 cases were index suicides (with no prior exposure to suicide) 16 exposed cases (exposed to at least one index suicide). Dependencies between six cases were observed. These cases functioned as both an index and exposed case within the descriptive network. All cases included in the descriptive network analysis were directly linked as friends, peers and relatives. The direction of exposure between index and exposed cases included in the descriptive network analysis is shown in **Table S2.4**.

Descriptive network analysis was conducted to identify transmission pathways among index and exposed cases. Transmission networks were identified among linked cases according to the relationship between those who died by suicide and the date of death. The first suicide in the network was defined as the index death and exposed cases were identified as subsequent deaths. All cases included in the descriptive network analysis were directly linked as friends, peers and relatives. The direction of exposure between index and exposed cases included in the descriptive network analysis is shown in **Table S2.3**.

Table S2.3 Demographic characteristics of linked and missing cases

Variable	Eligible (N=71)		Missing (N=49)		X ² P value
	N	(%)	N	(%)	
Sex (male)	44	(62)	35	(71.4)	0.28
Aged 18 years or less	35	(49.3)	22	(44.9)	0.64
Aboriginal or Torres Strait Island origins	15	(21.1)	9	(18.4)	0.71
Employed	22	(31)	16	(32.7)	0.85
Student	23	(32.4)	19	(38.8)	0.47
Residing in a remote location	9	(12.7)	<5	(<10)	0.56*

*Fishers exact test

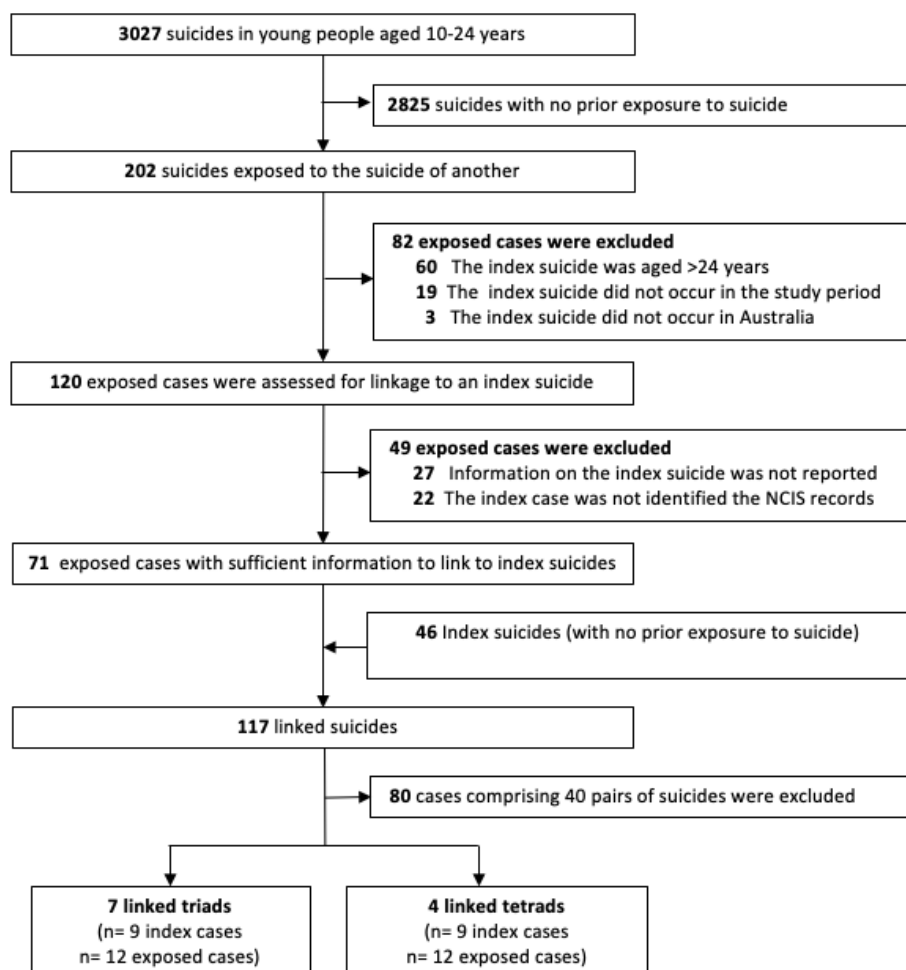


Figure 2.6 Flow chart of included studies in the descriptive network analysis of suicide clusters.

Table S2.4 Characteristics of clusters detected using the descriptive network analysis

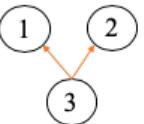
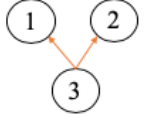
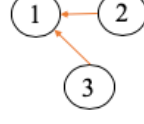
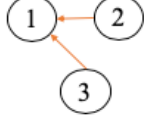
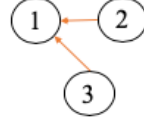
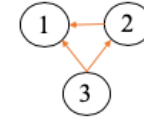
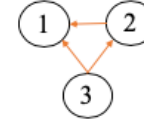
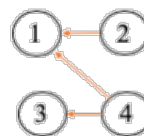
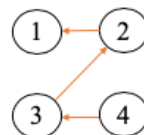
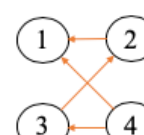
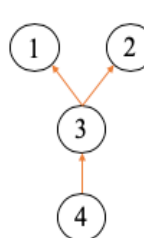
	Cluster description	Case ascertainment
	Triad: The third person (3) was exposed to two index suicides (1,2).	First and last name of index case(s) were identified in the police narrative of case (3). Cases were known to each other.
	Triad: The third person (3) was exposed to two index suicides (1,2).	Index case(s) were identified by date and location of death in the police narrative of case (3). Cases were described as friends.
	Triad: The second (2) and third (3) person who were both exposed to the same index suicide (1).	Index case identified by date and location in police narrative of case (2) and case (3). Cases were described as friends.
	Triad: The second (2) and third (3) person who were both exposed to the same index suicide (1).	First and last name of index case was identified in the coroner report of case (2) and case (3). Cases were described as friends and from the same friendship circle.
	Triad: The second (2) and third (3) person were both exposed to the same index suicide (1).	The Index case was identified by date and location of death in the coroner report of case (2) and (3). Cases were described as friends.
	Triad: The second (2) person was exposed to the index suicide (1). The third person was exposed to two suicides (1,2)	Index case(s) (1,2) were identified by date and location of death in the coroner report of cases (2) and (3). Cases were described as friends.
	Triad: The second (2) person was exposed to the index suicide (1). The third person who died by suicide was exposed to two suicides (1,2)	Index case(s) (1,2) were identified by date and location of death in the coroner report of cases (2) and (3). Cases were described as friends and in a relationship.
	Tetrad: The second person (2) was exposed to the index suicide (1). The fourth person (4) was exposed to two suicides (1,3).	The Index case (1) was identified by first and last name in the police report. Case (3) identified by date and location of death in police report. Cases were described as peers in the same grade and friends.
	Tetrad: The second (2) person was exposed to the index suicide (1). The third person (3) was exposed to the second suicide (2). The fourth person (4) was exposed to the third suicide (3).	Index case(s) (1,2,3) were identified by date and location of death in the coroner report. Peers from the same community and were known to each other.
	Tetrad: The second (2) person was exposed to the index suicide (1). The third person (3) was exposed to the second suicide (2). The fourth person (4) was exposed to two suicides (1,3).	Index case(s) (1,2,3) were identified by date and location of death in the police and coroner reports. Cases were described as relatives and friends.
	Tetrad: The third (3) person was exposed to two index suicides (1,2). The fourth person (4) was exposed to the third person (3) who died by suicide.	Index case(s) (1,2,3) were identified by location and date of death and method of death in both the police and coroner reports. Cases were described as friends.

Table S2.5 The scan statistic: Demographic characteristics

	Cluster suicides (N=69)		Non cluster (N=2958)		<i>P</i> value
	N	%	N	%	
Sex (male)	47	(68.1)	2167	(70.0)	1.00
Aged 18 years or less	21	(21.9)	984	(33.27)	
Aboriginal or Torres Strait Island origins	24	(34.8)	434	(14.67)	
Employed	20	(29.0)	974	(32.93)	0.58
Student	18	(29.4)	861	(29.11)	0.68
Residing in a remote location	28	(40.6)	207	(7.00)	0.00 *
Exposure to suicide	7	(11.29)	199	(6.73)	0.38

P*<0.05Table S2.6** Coronial inquests: Demographic characteristics

	Cluster suicides (N=40)		Non cluster suicides (N=2987)		<i>P</i> value
	N	%	N	%	
Sex (male)	27	(67.5)	2187	(73.22)	0.00 *
Aged 18 years or less	28	(70)	887	(29.7)	
Aboriginal or Torres Strait Island origins	22	(55)	436	(14.60)	0.00 *
Employed	9	(22.5)	985	(33.00)	0.22
Student	14	(35)	865	(28.96)	0.51
Residing in a remote location	20	(50)	215	(7.20)	0.00 *
Exposure to suicide	14	(35)	192	(6.43)	0.00 *

P*<0.05Table S2.7** Descriptive network analysis: Demographic characteristics

	Cluster suicides (N=37)		Non cluster suicides (N=2990)		<i>P</i> value
	N	%	N	%	
Sex (male)	26	(70.3)	2188	(73.18)	0.00 *
Aged 18 years or less	23	(62.2)	892	(29.83)	
Aboriginal or Torres Strait Island origins	8	(21.1)	450	(15.05)	0.40
Employed	12	(32.4)	982	(32.84)	1.00
Student	16	(43.2)	863	(28.86)	0.08
Residing in a remote location	5	(13.5)	230	(7.69)	0.31
Exposure to suicide	24	(64.9)	182	(6.09)	0.00 *

**P*<0.05

Chapter 3: Association of suicidal behaviour with exposure to suicide and suicide attempt: A systematic review and multilevel meta-analysis

This paper was published in PLOS Medicine (IF: 11.048) in March 2020 and is presented as the author-accepted version of the manuscript. I led this paper and undertook study design, data analysis, data interpretation and manuscript preparation and submission.

Abstract

Background: Exposure to suicidal behaviour may be associated with increased risk of suicide, suicide attempt, and suicidal ideation and is a significant public health problem. However, evidence to date has not reliably distinguished between exposure to suicide versus suicide attempt, nor whether the risk differs across suicide-related outcomes, which have markedly different public health implications. Our aim therefore was to quantitatively assess the independent risk associated with exposure to suicide and suicide attempt on suicide, suicide attempt, and suicidal ideation outcomes and to identify moderators of this risk using multilevel meta-analysis.

Methods and findings: We systematically searched MEDLINE, Embase, PsycINFO, CINAHL, ASSIA, Sociological Abstracts, IBSS, and Social Services Abstracts from inception to 19 November 2019. Eligible studies included comparative data on prior exposure to suicide, suicide attempt, or suicidal behaviour (composite measure—suicide or suicide attempt) and the outcomes of suicide, suicide attempt, and suicidal ideation in relatives, friends, and acquaintances. Dichotomous events or odds ratios (ORs) of suicide, suicide attempt, and suicidal ideation were analysed using multilevel meta-

analyses to accommodate the non-independence of effect sizes. We assessed study quality using the National Heart, Lung, and Blood Institute quality assessment tool for observational studies. Thirty-four independent studies that presented 71 effect sizes (exposure to suicide: $k = 42$, from 22 independent studies; exposure to suicide attempt: $k = 19$, from 13 independent studies; exposure to suicidal behaviour (composite): $k = 10$, from 5 independent studies) encompassing 13,923,029 individuals were eligible. Exposure to suicide was associated with increased odds of suicide (11 studies, $N = 13,464,582$; OR = 3.23, 95% CI = 2.32 to 4.51, $P < 0.001$) and suicide attempt (10 studies, $N = 121,836$; OR = 2.91, 95% CI = 2.01 to 4.23, $P < 0.001$). However, no evidence of an association was observed for suicidal ideation outcomes (2 studies, $N = 43,354$; OR = 1.85, 95% CI = 0.97 to 3.51, $P = 0.06$). Exposure to suicide attempt was associated with increased odds of suicide attempt (10 studies, $N = 341,793$; OR = 3.53, 95% CI = 2.63 to 4.73, $P < 0.001$), but not suicide death (3 studies, $N = 723$; OR = 1.64, 95% CI = 0.90 to 2.98, $P = 0.11$). By contrast, exposure to suicidal behaviour (composite) was associated with increased odds of suicide (4 studies, $N = 1,479$; OR = 3.83, 95% CI = 2.38 to 6.17, $P < 0.001$) but not suicide attempt (1 study, $N = 666$; OR = 1.10, 95% CI = 0.69 to 1.76, $P = 0.90$), a finding that was inconsistent with the separate analyses of exposure to suicide and suicide attempt. Key limitations of this study include fair study quality and the possibility of unmeasured confounders influencing the findings. The review has been prospectively registered with PROSPERO (CRD42018104629).

Conclusions: The findings of this systematic review and meta-analysis indicate that prior exposure to suicide and prior exposure to suicide attempt in the general population are associated with increased odds of subsequent suicidal behaviour, but these

exposures do not incur uniform risk across the full range of suicide-related outcomes. Therefore, future studies should refrain from combining these exposures into single composite measures of exposure to suicidal behaviour. Finally, future studies should consider designing interventions that target suicide-related outcomes in those exposed to suicide and that include efforts to mitigate the adverse effects of exposure to suicide attempt on subsequent suicide attempt outcomes.

3.1 Introduction

Suicide attempt and suicide are leading causes of global morbidity and mortality. Approximately 800,000 people die by suicide annually¹, of which about one-third are under the age of 30². The prevalence of suicide attempt is significantly greater than that of suicide death and is associated with heightened risk of later death by suicide^{3,4} as well as psychosocial adversities that persist later in life⁵. For every suicide death, it is estimated that approximately 135 people are affected⁶. Over the course of a lifetime, the proportion of people exposed to the suicide of a relative, friend, or acquaintance is approximately 21%⁷. Exposure to suicide has been linked to increased risk of physical disease and adverse mental health including depression, posttraumatic stress disorder, and complicated grief^{8,9}. The deleterious effects associated with exposure to suicide may also render some people, particularly adolescents and young adults, at increased risk of suicide and suicide attempt¹⁰.

Combined, the large number of people exposed to suicide and the potential increased risk of suicide-related outcomes (suicide, suicide attempt, and suicidal ideation) in others mean that exposure to suicide is a significant public health concern¹. This is reflected in several national suicide prevention strategies that recommend postvention

interventions for those bereaved by suicide¹¹, as well as several international frameworks for the prevention of suicide-related contagion, and the management of suicide and self-harm clusters¹²⁻¹⁵. These public health strategies have largely focused on exposure to suicide, despite a growing body of evidence that suggests that exposure to suicide attempt, the behaviour most proximal to suicide, may also be associated with increased risk of suicide-related outcomes¹⁶⁻¹⁹.

Distinguishing between the potential independent effects of exposure to suicide and suicide attempt is important since measures of morbidity and mortality have markedly different public health implications. Yet evidence regarding the independent effects of exposure to suicide and suicide attempt on subsequent suicide-related outcomes is unclear. A systematic review and meta-analyses by Geulayov and colleagues²⁰ showed that exposure to suicide and exposure to suicide attempt of a parent were associated with increased risk of suicide and suicide attempt in offspring. However, the authors pooled mean effect sizes across subgroups within studies and did not take into account the dependencies between effect sizes, an approach that may distort the results of the meta-analyses²¹. Another systematic review by Crepeau-Hobson and Leech¹⁹ reported that both exposure to suicide and exposure to suicide attempt were associated with subsequent suicide-related behaviour among friends or acquaintances. But the authors did not adequately control for studies that reported lifetime prevalence, leaving the causal direction between exposure to suicide attempt and subsequent suicide-related outcomes unclear.

Lack of guiding evidence has impeded translation of the evidence into practice. For example, it is not currently clear which populations may be at risk, nor whether the risk differs across outcomes involving suicide, suicide attempt, and suicidal ideation. Sveen

and Walby²² found inconclusive evidence supporting a relationship between exposure to suicide and increased risk of suicide-related behaviour in others. However, the authors combined studies reporting exposure in relatives and friends or acquaintances, which may incur different suicide risk. More recently, systematic reviews that investigated exposure to suicide in friends and acquaintances have reported a positive association between exposure to suicide and subsequent suicide-related outcomes^{19, 23}. Yet, as noted previously, the causal direction between exposure and outcome measures were confounded by the inclusion of studies that reported lifetime prevalence of exposure and outcome measures. Lastly, some studies included outcome measures that combined suicidal ideation with suicide attempt^{24, 25} or combined exposure to suicide and exposure to suicide attempt as a composite measure of exposure to suicidal behaviour²⁶⁻²⁸.

Composite measures of exposure to suicidal behaviour prevent us from identifying whether the observed effect is influenced by a true association or the result of a cumulative effect.

Consequently, the effects of prior exposure to suicide and suicide attempt on suicide-related outcomes have not been reliably quantified, and the factors that moderate this risk are not currently known. We therefore aimed to conduct a systematic review and multilevel meta-analysis investigating the independent association between prior exposure to suicide, suicide attempt, and suicidal behaviour (composite measure—suicide or suicide attempt) and subsequent suicide, suicide attempt, and suicidal ideation in relatives, friends, and acquaintances. In doing so, we aimed to quantify the association between exposure to suicide and suicide attempt and the full range of suicide-related outcomes, and to identify whether factors such as relationship to the person who engaged in the initial suicidal act, age of the study population, and study

design characteristics moderate this risk. By using multilevel meta-analyses, we were able to account for dependencies among multiple effect sizes taken from the same cohort within a study, an extremely common and challenging aspect of conducting meta-analyses of epidemiological studies²⁹.

3.2 Methods

This work adheres to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)³⁰ and MOOSE (Meta-analysis of Observational Studies in Epidemiology)³¹ guidelines and was prospectively registered with PROSPERO ([CRD42018104629](https://www.crd42018104629)). Deviations from the protocol include the use of exposure to suicidal behaviour (composite) and statistical analyses using multilevel meta-analyses. The association between exposure to suicide and suicide attempt and grief and mental health outcomes will be reported in a separate systematic review and meta-analysis.

3.2.1 Electronic search strategy

We searched MEDLINE, Embase, PsycINFO, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Applied Social Sciences Index and Abstracts (ASSIA), Sociological Abstracts, International Bibliography of the Social Sciences (IBSS), and Social Services Abstracts from inception through 19 November 2019 for observational studies examining the effects of exposure to suicide, suicide attempt, or suicidal behaviour on 1 or more outcomes relating to suicide, suicide attempt, or suicidal ideation. Search terms relating to exposure to suicide and suicide attempt as well suicide bereavement, suicide contagion, and suicide clusters were combined using Boolean logic (**Text S3.1**). The search was not limited by time, location, year of publication, or language (articles written in a language other than English were translated using Google

Translate). Additional articles were identified by scanning the reference lists of included articles and previous reviews. One author (NTMH) conducted the initial search and screening of titles and abstracts. Three authors independently screened the full text of each potentially eligible article (NTMH, AB, KA, and KW). Discrepancies were resolved by the first author (NTMH), who also contacted the corresponding authors of primary studies for additional information.

3.2.2 Study selection and eligibility criteria

Eligible studies reported dichotomous events (both the exposure and outcome were reported as having occurred or not occurred, yielding a 2×2 matrix) or odds ratios (ORs) for exposure to suicide, suicide attempt, or suicidal behaviour and subsequent suicide, suicide attempt, or suicidal ideation. Exposure to suicide, suicide attempt, or suicidal behaviour was determined from self-reported measures, informant interviews, official records (such as hospital admission records), or data linkage to death certificates. Outcomes involving suicide, suicide attempt, or suicidal ideation were determined from self-reported measures, informant interviews, or official records, such as death certificates, coroner reports, or hospital admission records. Cohort, case-control, and cross-sectional study designs were eligible if the study was reported in a peer-reviewed journal and the temporal sequence between the exposure and outcome was specified. For cross-sectional studies, the temporal sequence between exposure and outcome was established if the outcome measurement occurred after the exposure (e.g., the study asked participants if they had made a suicide attempt after exposure to the suicide of another). Participants of any age who were exposed to prior suicide or suicide attempt were eligible if the sample was mainly, or solely, drawn from the general population, as opposed to a clinical or other high-risk population (e.g., inpatients or

prison detainees). Eligible control groups included individuals who did not report prior exposure to suicide, suicide attempt, or suicidal behaviour in others.

Studies were excluded if findings from a non-exposed (control) group were not reported, or the control group was composed of participants exposed to other modes of death (e.g., accident or natural causes). Studies that reported estimates of lifetime prevalence as well as studies that did not establish the temporal sequence between exposure and suicide-related outcomes (e.g., the study reported 12-month prevalence of the outcome, but prior exposure to suicide was not indicated) were excluded. Finally, studies that reported outcomes following exposure to media reports of suicide (including fictional and non-fictional portrayals) or non-suicidal self-injury were excluded.

3.2.3 Data collection and coding

Two independent reviewers (NTMH and KK) extracted data using a standardised data collection form. A description of the a priori moderators of risk included in the study are presented in **Table S3.6**. Dichotomous data were favored over ORs. When dichotomous events were not available, unadjusted ORs were recorded. For studies with multiple follow-up time points, only data from the longest time point were extracted³². Studies that included participants from the same population during overlapping time periods (e.g., nationwide data registry studies that reported suicide deaths from overlapping time periods) were included only if the studies reported different relationships (e.g., relatives and friends and acquaintances) or different suicide-related outcomes. When studies combined measures of exposure to the suicide of a relative or friend, we contacted primary authors for disaggregated data. If these data were not available, the relationship between the exposed individual and the individual(s) who

engaged in suicidal behaviour was determined by a majority rule (the relationship that occurred most frequently as indicated in >50% of the total sample). Similarly, if the age of participants included a combination of youths and adults, the age of the population was categorised in favor of the age group that exceeded 50% of the overall population.

3.2.4 Multilevel meta-analysis rationale and data analysis

Since 16/34 (47%) studies reported multiple exposure and/or outcome measures in the same sample of participants, the assumption of independent estimates for a traditional meta-analysis was not met. We therefore used a 3-level meta-analysis, which parallels traditional random effects meta-analyses. The main difference is that dependent effect sizes (due to multiple subgroups or outcome measures within studies) are nested within studies (level 2) before these are pooled across studies (level 3). Thus, $\tau_{(2)}^2$ is the variance within studies while $\tau_{(3)}^2$ is the variance between studies. This approach allows for the investigation of heterogeneity not only between but also within studies³³. For clarity, we use the general term “multilevel” throughout to describe our analyses.

We conducted a multilevel meta-analysis with the maximum likelihood estimation method using the metaSEM package³⁴ for R version 3.6.0. For the main analysis, we used dichotomous event data to calculate the pooled OR with the accompanying 95% confidence interval (CI) for risk of suicide, suicide attempt, and suicidal ideation within exposed and non-exposed individuals. When event data were not available, we used unadjusted ORs. Meta-analyses were conducted separately for exposure to suicide, suicide attempt, and suicidal behaviour. Heterogeneity was quantified as variance in true effects within ($\tau_{(2)}^2$) and between ($\tau_{(3)}^2$) studies. We also report the I^2 statistic, which represents the proportion of variance in true effects out of total variance for each

level (i.e., $I_{(2)}^2$ and $I_{(3)}^2$), along with its 95% confidence interval. Maximum likelihood mixed-effects analyses were used to examine effect moderators via subgroup analysis and to explain heterogeneity (quantified as R^2) for each level. Since the multilevel model does not provide study-level effect estimates, forest plots present the mean OR of each study but report the pooled 3-level estimate. Small study effect (“publication bias”) was assessed by visually inspecting funnel plots of mean log ORs against standard error for asymmetry³⁵. When at least 10 studies were available for analysis, we formally assessed funnel plot asymmetry using a multilevel analogue of Egger’s test of the intercepts³⁶.

3.2.5 Risk of bias and quality assessment

Study quality was assessed using the National Heart, Lung, and Blood Institute quality assessment tool for observational studies³⁷. The original tool contains 14 criteria that determine potential sources of bias in the study population and selection of participants, outcome and exposure measurement, blinding, confounding, and attrition. An overall rating of “good,” “fair,” or “poor” was provided for each independent study. Three independent reviewers conducted assessments (NTMH, AP, and AC), and any discrepancies were settled through discussion and finalised by the primary author (NTMH). Results

3.2.6 Study selection

The initial search identified 21,868 records, of which 8,320 were duplicates. A total of 13,548 records were screened based on title and abstract (**Figure 3.1**). The full-text versions of 760 records were assessed, 10 of which were obtained from searching the reference lists of existing reviews. The authors of 6 studies were contacted³⁸⁻⁴³, and

information or additional data provided for 2 studies^{39, 41}. A total of 167 records reported outcomes relating to suicide, suicide attempt, or suicidal ideation. Of these, 73 articles reported lifetime prevalence estimates, 35 studies involved overlapping populations or superseded time points, and 2 studies did not report ORs or accompanying effect sizes: These articles were therefore excluded from the meta-analysis. One study⁴⁴ was excluded because it reported an OR of 36.4, and 1 study⁴⁵ was excluded because it reported an OR of 18; both studies were prone to artifacts introduced by quasi-separation (**Text S3.2, Table S3.7**). The final dataset included 34 independent studies, which comprised 71 effect sizes (exposure to suicide: $k = 42$ across $n = 22$ studies; exposure to suicide attempt: $k = 19$ across $n = 13$ studies; exposure to suicidal behaviour: $k = 10$ across $n = 5$ studies).

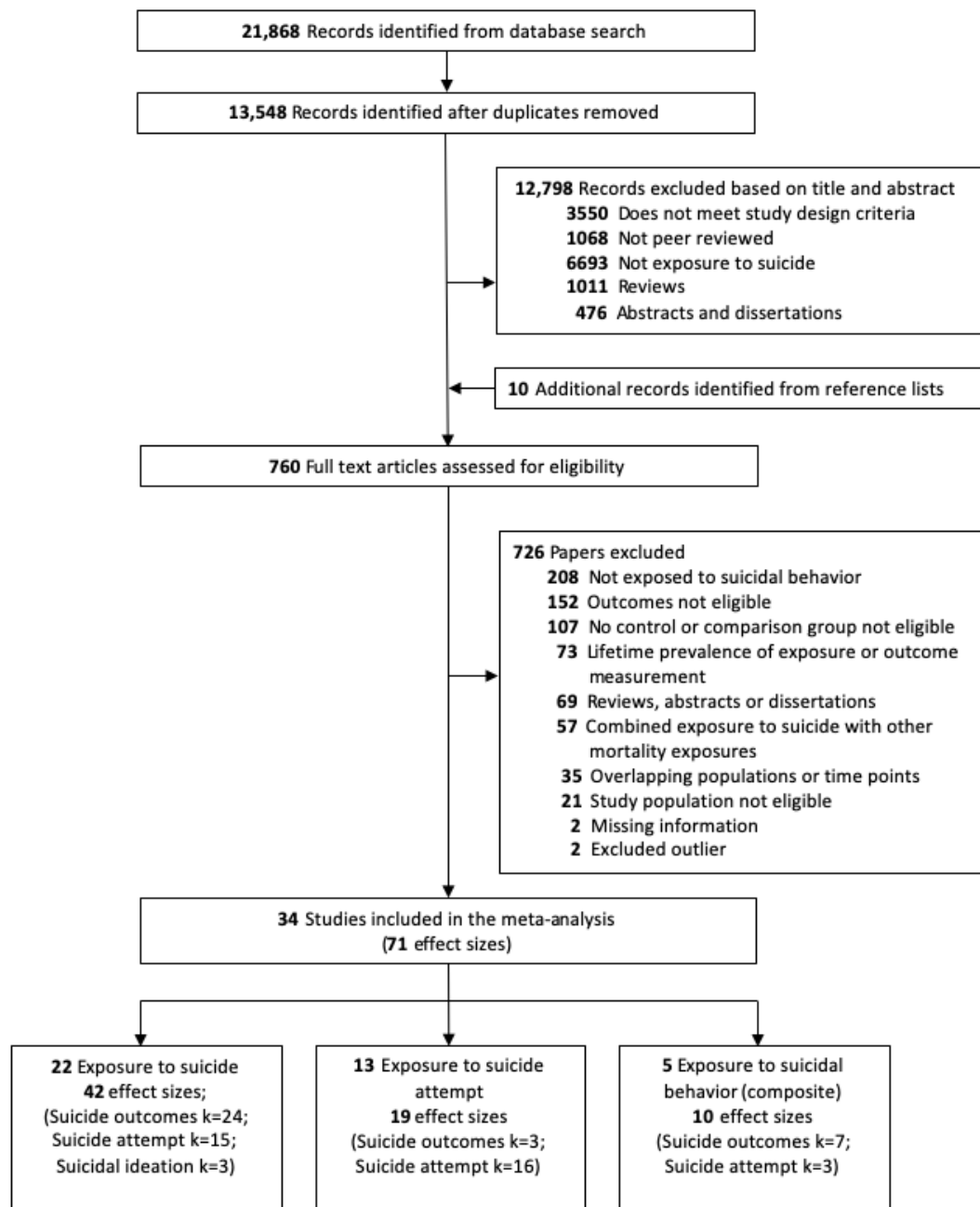


Figure 3.1 Flowchart of included studies.

3.2.7 Characteristics of studies

Thirty-four studies were included in the meta-analysis ($N = 13,923,029$; **Table 3.2**). In terms of exposure to suicide, 22 studies ($N = 13,607,708$) provided a total of 42 effect sizes for suicide ($k = 24$), suicide attempt ($k = 15$), and suicidal ideation ($k = 3$). For exposure to suicide attempt, 13 studies ($N = 342,516$) provided a total of 19 effect sizes for suicide ($k = 3$) and suicide attempt ($k = 16$). For exposure to suicidal behaviour (composite measure—suicide or suicide attempt), 5 studies ($N = 2,145$) provided a total of 10 effect sizes for suicide ($k = 7$) and suicide attempt ($k = 3$). Studies were from a range of geographic settings including Australia/New Zealand⁴⁶⁻⁴⁸, North America^{16, 18, 28, 49-57}, Europe^{17, 41, 58-63}, East Asia^{26, 27, 64-69}, Middle East^{39, 42}, and South America⁷⁰. Overall, 20/34 studies involved youths aged 25 years or less. Overall exposure was determined by informant interviews in 14/34 (41%) studies, self-report measures in 12/34 (35%) studies, and official death records in 8/34 (24%) studies. A total of 6/34 (18%) studies reported separate effect sizes for exposure to suicide and exposure to suicide attempt, and 5/34 (15%) studies reported effect sizes for both exposure in relatives and exposure in friends. In terms of outcome measurements, most studies (23/34, 68%) used official hospital admission or death records, followed by self-report measures (10/34, 29%) and informant interviews (1/34, 3%). One study (1/34, 3%) reported outcomes for both suicide attempt and suicidal ideation following exposure to suicide. No studies reported suicidal ideation outcomes following exposure to suicide attempt or suicidal behaviour. Lastly, 3 studies included exposure and outcome measurements of deliberate self-harm, irrespective of intent^{48, 59, 62}. The remainder studies did not define suicide attempt^{16, 18, 42, 52, 54, 57, 59, 70, 71}, or defined suicide attempt as an act involving explicit intent to die^{16, 17, 28, 39, 47, 49-51, 53, 56, 64}.

Table 3.1 Characteristics of included studies

Study, location, study design	Exposed population, mean age or age range (years), percent female, total sample size	Exposure	Definition of exposure	Outcome(s)	Definition of outcome(s)	Exposure ascertainment	Study quality
Agerbo 2003, Denmark, case–control	Adult ^b , age range = 9–44, 24.52% female, <i>N</i> = 4,444,297	Suicide of relative (any relative) ^a	Official records: Cause of death register. Exposure(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), intentional self-harm (ICD-10: X60–X84), and sequelae of intentional self-harm (ICD-10: Y870).	Suicide	Official death records: Cause of death register. Outcome(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), intentional self-harm (ICD-10: X60–X84), and sequelae of intentional self-harm (ICD-10: Y870).	The outcome occurred after the date of the exposure determined through data linkage.	Good
Almeida 2012, Australia, cross-sectional	Adult, mean age = 70.5, age range = 60–101, 58.7% female, <i>N</i> = 21,290	Suicide of relative (first-degree relative) ^b	Self-report: Participants were asked if any immediate family member had died by suicide.	Suicidal ideation	Self-report: Participants completed the Depressive Symptom Inventory Suicidality Subscale.	Determined by current suicidal ideation (persistent over the last 2 weeks). Exposure occurred at least 2 months prior.	Good
Brent 1996a, US, cohort	Youth, mean age = 20.8, 46.6% female, <i>N</i> = 341	Suicide of friend or acquaintance	Informant: Suicide death in the family.	Suicide attempt	Self-report: Participants were asked if they have engaged in deliberate self-harm with intent to die.	New onset of suicide attempt since exposure.	Good
Brent 1996b, US, cohort	Youth, mean age = 20.2, 50% female, <i>N</i> = 44	Suicide of relative (sibling)	Self-report: Suicide death in the family.	Suicide attempt	Self-report: Participants were asked if they have engaged in deliberate self-harm with intent to die.	New onset of suicide attempt since exposure.	Good

Christiansen 2011, Denmark, case-control	Youth, mean age = 17.49, 78.75% female, <i>N</i> = 69,649	Suicide of relative (parent)	Official records: Exposure(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959) and intentional self-harm (ICD-10: X60–X84).	Suicide attempt	Hospital admission records: Outcome(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), intentional self-harm (ICD-10: X60–X84), self-poisoning event of undetermined intent (ICD-10: Y10–Y34), injury of muscle and tendon at neck level (ICD-10: S617–S619), sequelae of poisoning by drugs, medicaments and biological substances (ICD-10: T36–T60), and toxic effect of unspecified substance (ICD-10: T65).	The outcome occurred after the date of the exposure determined through data linkage.	Good
Gravseth 2010, Norway, cohort	Adult ^b , age range = 19–37, 48.82% female, <i>N</i> = 610,359	Suicide of relative (parent)	Official records: Exposure(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959) and intentional self-harm ICD-10: (X60–X84).	Suicide	Official death records: Outcome(s) determined by ICD codes for suicide and self-inflicted injury (ICD-9: E950–E959) and intentional self-harm (ICD-10: X60–X84).	The outcome occurred after the date of the exposure determined through data linkage.	Good
Giupponi 2018, Italy, case-control ^a	Adult, mean age = 48.25, 38.16% female, <i>N</i> = 262	Suicide of relative (any relative)	Informant: Participants were asked if there was a history of suicide in the family. Informed by at least 2 people including relatives or close friends.	Suicide	Official death records: Cause of death hospital forensic post-mortem records.	Psychological autopsy—suicide occurred after exposure.	Fair
Lee 2018, Taiwan, cohort	Youth, 63.4% aged <17, 47.75% female, <i>N</i> = 438,330	Suicide of relative (parent)	Official records: Taiwan death registry. Exposure(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), intentional self-harm (ICD-10: X60–X84), and sequelae of intentional self-harm (ICD-10: Y870).	Suicide	Official death records: Taiwan death registry. Outcome(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), intentional self-harm (ICD-10: X60–X84), and sequelae of intentional self-harm (ICD-10: Y870).	The outcome occurred after the date of the exposure determined through data linkage.	Good

Liu 2019, China, case-control ^a	Adult, mean age = 60.87, 43.15% female, <i>N</i> = 380	Suicide of relative (any relative)	Informant: Informants were asked if there was a history of suicide in the family. Informed by at least 1 relative or close friend.	Suicide	Official death records: Center for Disease Control and Prevention records of suicide.	Psychological autopsy—suicide occurred after exposure.	Fair
Conner 2007, China, case-control	Adult ^b , age range <18 to 55+ (64% aged <35), 76% female, <i>N</i> = 554	Suicide of friend or acquaintance	Self-report: Participants were asked if there was a history of suicide in an associate or relative.	Suicide attempt	Hospital admission records: Hospital admission for intentional suicide attempt.	All participants were hospitalised for suicide attempt at the time that prior exposure was measured.	Fair
Foster 1999, Ireland, case-control ^a	Adult ^b , age range <20 to 79 (32% aged <29), 28.2% female, <i>N</i> = 230	Suicide of relative (any relative)	Informant: Informants were asked if there was a family history of suicide. Informants not indicated but were “bereaved” by suicide.	Suicide	Official death records: Coroner-determined suicide death.	Psychological autopsy—suicide occurred after exposure.	Fair
Gray 2014, US, case-control ^a	Adult, mean age = 39.9, 32.5% female, <i>N</i> = 423	Suicide of relative (any relative)	Informant: Informants were asked if there was a family history of suicide. Informed by next of kin.	Suicide	Official death records: Cause of death register, Utah Office of the Medical Examiner.	Psychological autopsy—suicide occurred after exposure.	Fair
Katibeh 2018, Iran, case-control	Youth, mean age = 15.5, age range ≤ 18, percent female not reported, <i>N</i> = 300	Suicide of relative (parent)	Self-report: Participants were asked if there was a history of suicide in their parents.	Suicide attempt	Hospital admission records: Hospital admission records for suicide attempt.	All participants were hospitalised for suicide attempt at the time that prior exposure was measured.	Poor
Swanson & Colman 2013, Canada, cohort (cross-sectional analyses)	Youth, age range = 12–15, 50.1% female, <i>N</i> = 22,064	Suicide of friend or acquaintance	Self-report: Participants were asked whether anyone in their school had died by suicide (schoolmate’s suicide) and whether they personally knew anyone who had died by suicide.	Suicide attempt and suicidal ideation	Self-report (suicide attempt): Participants were asked to report the number of suicide attempts they had made in the past year, and participants were asked if they had seriously considered attempting suicide in the past year.	Prior exposure measured at baseline, and subsequent suicide attempt was based on participants who reported having made a suicide attempt within the 2-year follow-up period.	Fair

Tidemalm 2011, Sweden, case-control	Adult ^b , population-based study (all ages), age/sex not reported, <i>N</i> = 7,969,645	Suicide of relative (sibling, parent, or spouse)	Official records: Cause of death register. Exposure(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), intentional self-harm (ICD-10: X60–X84), and sequelae of intentional self-harm (ICD-10: Y870).	Suicide	Official death records: Cause of death register. Outcome(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), intentional self-harm (ICD-10: X60–X84), and sequelae of intentional self-harm (ICD-10: Y870).	The outcome occurred after the date of the exposure.	Good
Vijayakumar 1999, India, case-control ^a	Adult ^b , age range = 15 to 60+ (48.5% aged ≤24), 45.0% female, <i>N</i> = 200	Suicide relative (any relative)	Informant: Informants were asked if there was a history of completed suicide in the family. Informed by family members.	Suicide	Official death records: Coroner-determined suicide death.	Psychological autopsy—suicide occurred after exposure.	Fair
Brent 2015, US, cohort	Youth, mean age = 17.7, 48.1% female, <i>N</i> = 42	Suicide attempt of relative (parent)	Informant: Informants were asked if a family member had made a suicide attempt, defined as a self-destructive act that resulted in potential or actual tissue damage with inferred or explicit intent to die. Informed by parents of cases and controls.	Suicide attempt	Self-report: Participants were asked if they had made a suicide attempt, defined as a self-destructive act that resulted in potential or actual tissue damage with inferred or explicit intent to die.	Number of new events of suicide attempt during 5-year follow-up period.	Good
Gould 1996, US, case-control ^a	Youth, age range ≤ 18, 20.1% female, <i>N</i> = 267	Suicide attempt of relative (parent)	Informant: Informants were asked if there was a history of first- and second-degree relatives who died by suicide or made a suicide attempt. Informed by parents or other adult who lived with the deceased.	Suicide	Official death records: Coroner-determined suicide death.	Psychological autopsy—suicide occurred after exposure.	Fair
Hu 2017, Australia, case-control	Youth, age range = 10–19, 62.4% female, <i>N</i> = 150,171	Suicide attempt of relative (parent)	Official records: Data linkage records for admission to hospital for deliberate self-harm.	Suicide attempt	Hospital admission records: Outcome(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), injury undetermined	The outcome occurred after the date of the exposure determined through data linkage.	Good

					whether accidentally or purposely inflicted (ICD-8/9: E980–E989), intentional self-harm (ICD-10: X60–X84), and sequelae of intentional self-harm (ICD-10: Y870).		
Lewinsohn 1994, US, cohort	Youth, mean age = 16.5, age range = 14–18, 54% female, <i>N</i> = 1,508	Suicide attempt of friend or acquaintance	Self-report: Participants were asked if they knew a friend who had attempted suicide.	Suicide attempt	Self-report: Participants were asked if they have made an attempt to kill themselves.	Prior exposure measured at baseline, and subsequent suicide attempt was based on participants who reported having made a suicide attempt within the 1-year follow-up period.	Good
Mittendorfer-Rutz 2008, Sweden, case-control	Youth, mean age = 19.1, 66.9% female, <i>N</i> = 158,840	Suicide attempt of relative (first-degree relative)	Official records: Hospital admissions inpatient care register. Exposure(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), injury undetermined whether accidentally or purposely inflicted (ICD-8/9: E980–E989), intentional self-harm (ICD-10: X60–X84), and sequelae of intentional self-harm (ICD-10: Y870).	Suicide attempt	Hospital admission records: Outcome(s) determined by ICD codes for suicide and self-inflicted injury (ICD-8/9: E950–E959), injury undetermined whether accidentally or purposely inflicted (ICD-8/9: E980–E989), intentional self-harm (ICD-10: X60–X84), and sequelae of intentional self-harm (ICD-10: Y870).	All participants were hospitalised for deliberate self-harm at the time that prior exposure was measured.	Good
Nrugham 2008, Norway, cohort	Youth, mean age = 14.9, age range = 15–20, 50.8% female, <i>N</i> = 265	Suicide attempt of friend or acquaintance	Self-report: Participants were asked if they knew a friend who had attempted suicide.	Suicide attempt	Self-report: Participants were asked if they have ever tried to intentionally commit suicide.	Prior exposure measured at baseline, and subsequent suicide attempt was based on participants who reported having made a suicide attempt within the 1-year follow-up period.	Poor

Hishinuma 2018, US, cohort	Youth, age range = 13–21, 54% female, <i>N</i> = 2,083	Suicide attempt of relative (any relative) and suicide attempt of friend or acquaintance	Self-report: Participants were asked if a family member or friend had tried to commit suicide.	Suicide attempt	Self-report: Participants were asked if they had tried to commit suicide in the past 6 months (Major Life Events Scale).	Prior exposure measured at baseline, and subsequent suicide attempt was based on participants who reported having made a suicide attempt during the 5-year follow-up period.	Good
Ahmadi 2015, Iran, case-control	Youth, mean age = 29 (60% aged ≤25), 76.0% female, <i>N</i> = 453	Suicide of relative (first and second degree) and suicide attempt of relative (first and second degree)	Self-report: Suicide history in family and sibling, and parent's history of suicide attempt.	Suicide attempt	Hospital admission records: Hospital admission for deliberate self-inflicted immolation with suicide intent.	All participants were hospitalised for suicide attempt at the time that prior exposure was measured.	Fair
Chachamovich 2015, Canada, case-control ^a	Youth, mean age = 23.4 ^d age range = 1–25, 7.5% female, <i>N</i> = 240	Suicide of relative (any relative); suicide attempt of relative (any relative)	Informant: Informants were asked if there was a history of suicide completion or suicide attempt in family. Informed by spouses, parents, or close friends of the deceased.	Suicide	Official death records: Coroner-determined suicide death.	Psychological autopsy—suicide occurred after exposure.	Fair
Chan 2018, New Zealand, cross-sectional	Youth, age range = 13–19 (98.7% aged ≤17), 54.3% female, <i>N</i> = 8,497	Suicide of relative (any relative) and friend or acquaintance; suicide attempt of relative (any relative) and friend or acquaintance	Self-report: Participants were asked if there was a history of suicide among their family or friends. For exposure to suicide attempt, participants were asked if anyone in their family or friends ever tried to kill themselves (attempted suicide?).	Suicidal ideation	Self-report: Participants were asked if they have made an attempt to kill themselves.	Exposure occurred >1 year ago, but ideation based on symptoms in the past year.	Fair
Garfinkel 1982, Canada, case-control	Youth, mean age = 15.2, age range = 6–21, 75.4% female, <i>N</i> = 1,010	Suicide of relative (parent); suicide attempt of relative (parent)	Official records: Chart review of family history of suicide attempts or suicide (completed suicide).	Suicide attempt	Hospital admission records: Hospital admission for suicide attempt with a conscious intent to die.	All participants were hospitalised for suicide attempt at the time that prior exposure was measured.	Poor

Palacio 2007, Colombia, case-control ^a	Adult ^b , median age = 29, 19.4% female, <i>N</i> = 216	Suicide of relative (any relative); suicide attempt of relative (any relative)	Informant: Informants were asked if there was a history of suicide or suicide attempt in the family. Informed by relatives and medical documents.	Suicide	Official death records: Medical legal records of suicide cause of death.	Psychological autopsy—suicide occurred after exposure.	Poor
Thompson 2011, US, cohort	Youth, mean age = 15.5, age range = 11–21, 49.1% female, <i>N</i> = 18,924	Suicide of relative (any relative) ^a and friend or acquaintance; suicide attempt of relative (any relative) ^a and friend or acquaintance	Self-report: Participants were asked if a friend or family member had died by suicide. For exposure to suicide attempt, participants were asked if a friend or family member had made a suicide attempt.	Suicide attempt	Self-report: Participants were asked whether they had attempted suicide within the 12 months before the survey.	Prior exposure measured at baseline, and subsequent suicide attempt was based on participants who reported having made a suicide attempt during wave III (7 years later).	Fair
Phillips 2002, China, case-control ^a	Adult ^b , age range = 10 to 75+ (70% aged ≤30), 52% female, <i>N</i> = 1,055	Suicidal behaviour (composite) of relative (any relative)	Informant: Informants were asked if there was a family history of suicidal behaviour (suicide attempts or suicide). Informed by family members of the deceased or close associates.	Suicide	Official death records: Medical legal records of suicide cause of death.	Psychological autopsy—suicide occurred after exposure.	Poor
Cheng 2000, Taiwan, case-control ^a	Adult ^b , mean age = 43.9, age range = 15–60, 39.8% female, <i>N</i> = 339	Suicidal behaviour (composite) of relative (any relative)	Informant: Informants were asked if there was a family history of suicidal behaviour (suicide attempts or suicide). Informed by family members of the deceased.	Suicide	Official death records: Suicide as determined by prosecutor and coroner reports.	Psychological autopsy—suicide occurred after exposure.	Poor
Maniam 1994, US, case-control ^a	Adult ^b , mean age = 28.5, age range = 11–75, 50% female, <i>N</i> = 40	Suicidal behaviour (composite) of relative (any relative)	Informant: Informants were asked if there was a family history of suicidal behaviour (suicide attempts or suicide). Informed by parents, spouses, or other adults who lived with the deceased.	Suicide	Official death records: Medical legal records of suicide cause of death.	Psychological autopsy—suicide occurred after exposure.	Poor

Jollant 2014, US, case-control ^a	Youth, age range = 15–64 (56.25% aged ≤24), 25% female, <i>N</i> = 45	Suicidal behaviour (composite) of relative (any relative)	Informant: Informants were asked if there was a family history of suicidal behaviour (suicide attempts or suicide). Informed by members of the community who knew the deceased.	Suicide	Informant: Suicide death reported by informants.	Psychological autopsy—suicide occurred after exposure.	Poor
Mercy 2001, US, case-control	Youth, age range = 13–35 (50.3% aged ≤24), 54.5% female, <i>N</i> = 666	Suicidal behaviour (composite) of relative (any relative); suicidal behaviour (composite) of friend or acquaintance	Self-report: Participants were asked if their friends or family had committed suicide or made a suicide attempt.	Suicide attempt	Hospital admission records: Hospital admission for nearly lethal suicide attempt, defined as those in which the person probably would have died if they had not received emergency medical or surgical intervention or in which the attempter unequivocally used a method with a high case fatality ratio (i.e., a gun or a noose) and sustained an injury, regardless of severity.	All participants were hospitalised for suicide attempt at the time that prior exposure was measured.	Fair

^aPsychological autopsy study.

^bMajority of the population aged >24 years and therefore categorised as adults.

^cExposure was a composite measure of suicide in a relative or friend; however, the majority were exposed to a friend's suicide.

^dExposure was a composite measure of suicidal behaviour, but exposure to suicide was only 1%, and therefore the exposure was coded as exposure to suicide attempt.

ICD, International Classification of Diseases.

3.2.8 Study quality

Studies were most commonly rated fair (13/34) and good (13/34), followed by poor (8/34; **Table S3.8-S3.9**). The 13 good-quality studies tended to comprise cohort or case-control study designs and had clearly defined and valid exposure and outcome measures that were verified using official hospital or death records. The 8 studies that were rated poor tended to combine exposure to suicide and suicide attempt into a composite measure of exposure to suicidal behaviour, did not provide adequate definitions of exposure to suicide or suicide attempt, and did not provide information on case ascertainment for suicide-related outcomes.

3.2.9 Results of the multilevel meta-analysis

Exposure to suicide. Across 42 effect sizes from 22 studies, exposure to suicide was associated with 2.94-fold (95% CI = 2.30 to 3.75, $P < 0.001$; **Figure 3.2**) increased odds of suicidal behaviour (suicide or suicide attempt). Heterogeneity within and between studies was comparable ($\tau^2_{(2)} = 0.13$, $I^2_{(2)} = 47\%$, 95% CI 15% to 94%; $\tau^2_{(3)} = 0.132$, $I^2_{(3)} = 48\%$, 95% CI 1% to 81%). The funnel plot revealed evidence of asymmetry, which may indicate evidence of small study effect (Egger's intercept = 0.675, 1-tailed $P = 0.06$; **Figure S3.5**). Results from the subgroup analysis showed that exposure to suicide was associated with increased odds of suicide ($k = 24$, OR = 3.23, 95% CI = 2.32 to 4.51, $P < 0.001$) and suicide attempt ($k = 15$, OR = 2.91, 95% CI = 2.01 to 4.23, $P < 0.001$). However, there was limited evidence of an association with suicidal ideation ($k = 3$, OR = 1.85, 95% CI = 0.97 to 3.51, $P = 0.06$; Q between subgroups = 2.22, $df = 2$, $P = 0.33$, $R^2_{(2)} = 11.8\%$, $R^2_{(3)} = 0\%$). The odds of later suicidal behaviour were comparable when the exposure to suicide occurred in relatives ($k = 34$,

OR = 3.07, 95% CI = 2.35 to 4.01) and friends and acquaintances ($k = 8$, OR = 2.42, 95% CI = 1.50 to 3.91; $Q = 0.77$, $df = 1$, $P = 0.38$, $R^2_{(2)} = 0\%$, $R^2_{(3)} = 2.7\%$). No further significant moderators relating to study design characteristics were identified (**Table 3.3**).

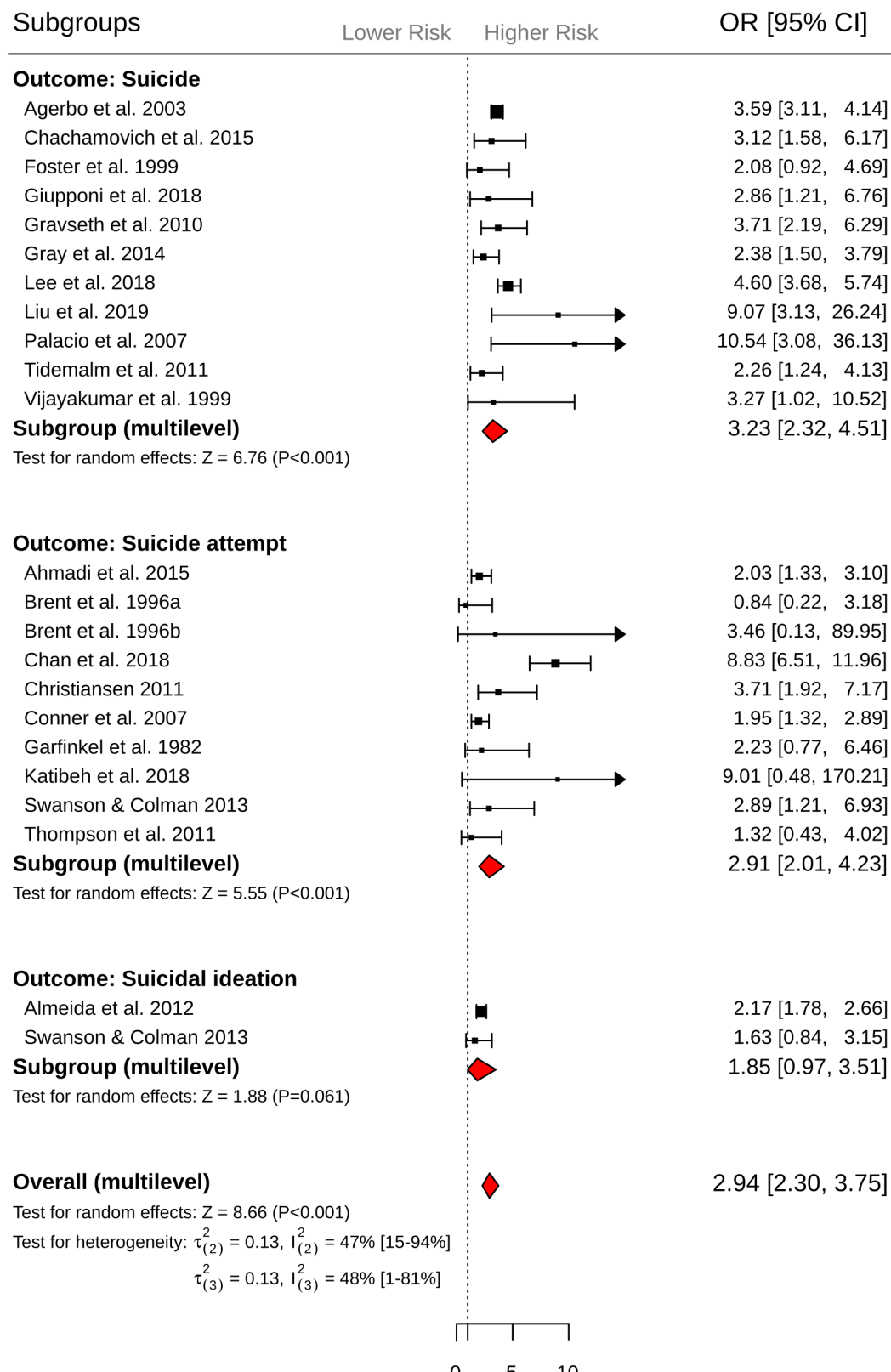


Figure 3.2 Forest plots of exposure to suicide and subsequent suicide, suicide attempt, and suicidal ideation outcome. CI= Confidence intervals. OR= Odds ratio.

Table 3.2 Results of moderator analyses of exposure to suicide across suicide, suicide attempt, and suicidal ideation outcomes

Moderator	Number of effect sizes	Odds ratio (95% confidence interval)	<i>P</i> value	$R^2_{(2)}$	$R^2_{(3)}$	ANOVA between-group <i>P</i> value
Proximity						
Relative	34	3.07 (2.35 to 4.01)	<0.001			
Friend or acquaintance	8	2.42 (1.50 to 3.91)	<0.001	<0.001	0.03	0.38
Population at risk						
Adult	24	2.80 (2.00 to 3.92)	<0.001			
Youth	18	3.04 (2.14 to 4.32)	<0.001	<0.001	0.06	0.74
Outcome measurement						
Informant interview	2	1.53 (0.63 to 3.73)	0.35			
Official records	30	3.10 (2.30 to 4.17)	<0.001			
Self-report	10	2.97 (1.86 to 4.75)	<0.001	0.04	0.04	0.34
Exposure measurement						
Informant interview	7	3.53 (2.13 to 5.83)	<0.001			
Official records	20	2.84 (1.93 to 4.18)	<0.001			
Self-report	15	2.66 (1.78 to 3.97)	<0.001	<0.01	<0.01	0.68
Psychological autopsy						
No	34	2.64 (2.64 to 3.50)	<0.001			
Yes	8	3.71 (2.38 to 5.78)	<0.001	0.03	0.07	0.21
Study design						
Case-control	29	2.85 (2.14 to 3.80)	<0.001			
Cohort	10	2.13 (1.35 to 3.36)	0.01			
Cross-sectional	3	4.98 (2.73 to 9.08)	<0.001	<0.01	0.47	0.12
Study quality						
Good	23	2.61 (1.86 to 3.67)	<0.001			
Fair	15	3.03 (2.13 to 4.30)	<0.001			
Poor	4	5.15 (1.97 to 13.48)	<0.001	<0.001	0.09	0.41

ANOVA, analysis of variance.

Exposure to suicide attempt. Across 19 effect sizes from 13 studies, exposure to suicide attempt was associated with 2.99-fold (95% CI = 2.19 to 4.09, $P < 0.001$; **Figure 3.3**) increased odds of suicidal behaviour. Heterogeneity within studies was 9% ($\tau^2_{(2)} = 0.022$, $I^2_{(2)} = 9\%$, 95% CI 1% to 54%), while heterogeneity between studies was substantially larger ($\tau^2_{(3)} = 0.22$, $I^2_{(3)} = 88\%$, 95% CI 42% to 97%). Inspection of the funnel plot did not reveal evidence of small study effect (Egger's intercept = -0.453 , $P = 0.33$; **Figure S3.6**). Results from subgroup analysis revealed that exposure to suicide attempt was associated with greater odds of subsequent suicide attempt ($k = 16$, OR = 3.53, 95% CI = 2.63 to 4.73, $P < 0.001$) but not suicide death ($k = 3$, OR = 1.64, 95% CI = 0.90 to 2.98, $P = 0.10$; Q between subgroups = 4.22, $df = 1$, $P = 0.04$, $R^2_{(2)} = 0\%$, $R^2_{(3)} = 3.8\%$). Significant between-group differences were observed for study design, with cross-sectional studies reporting greater odds of subsequent suicidal behaviour ($k = 2$, OR = 8.23, 95% CI = 4.70 to 14.30, $P < 0.001$) compared to case-control studies ($k = 10$, OR = 2.74, 95% CI = 2.04 to 3.69, $P < 0.001$) and cohort studies ($k = 7$, OR = 2.69, 95% CI = 1.82 to 3.99, $P < 0.001$; Q between subgroups = 7.35, $df = 2$, $P = 0.02$, $R^2_{(2)} = 0\%$, $R^2_{(3)} = 72.8\%$). Finally, moderator analyses revealed that psychological autopsy studies ($k = 3$, OR = 1.64, 95% CI = 0.90 to 2.99, $P = 0.127$) were associated with reduced odds of suicidal behaviour compared to non-psychological autopsy studies ($k = 16$, OR = 3.53, 95% CI = 2.63 to 4.73, $P < 0.001$, Q -between subgroups = 4.22, $df = 1$, $P = 0.03$, $R^2_{(2)} = 0\%$, $R^2_{(3)} = 38.4\%$). No further significant differences were observed for the remaining moderators (**Table 3.4**).

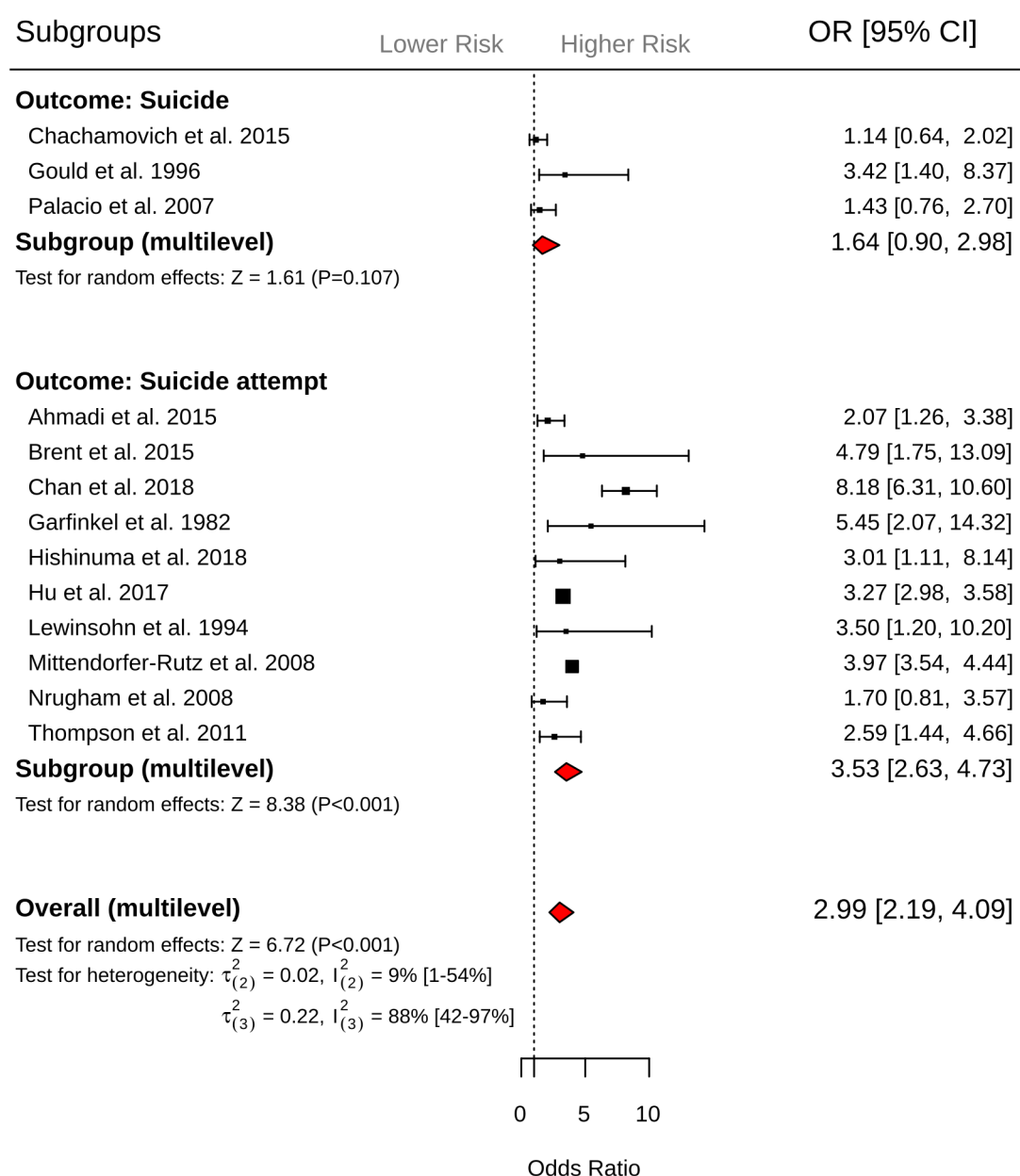


Figure 3.3 Forest plots of exposure to suicide attempt and subsequent suicide and suicide attempt outcomes. CI = Confidence intervals. OR = Odds ratio.

Table 3.3 Results of moderator analyses of exposure to suicide attempt across suicide, suicide attempt and suicidal ideation outcomes

Moderator	Number of effect sizes	Odds ratio (95% confidence interval)	<i>P</i> value	$R^2_{(2)}$	$R^2_{(3)}$	ANOVA between-group <i>P</i> value
Proximity						
Relative	14	3.14 (2.25 to 4.38)	<0.001			
Friend or acquaintance	5	2.64 (1.72 to 4.03)	<0.001	0.14	<0.001	0.39
Population at risk						
Adult	1	1.43 (0.48 to 4.32)	0.52			
Youth	18	3.19 (2.35 to 4.32)	<0.001	<0.001	0.16	0.18
Outcome measurement						
Official records	10	2.60 (1.75 to 3.87)	<0.001			
Self-report	9	3.62 (2.30 to 5.68)	<0.001	<0.01	0.13	0.29
Exposure measurement						
Informant interview	3	1.64 (0.90 to 2.99)	0.12			
Official records	5	3.60 (2.12 to 6.10)	<0.001			
Self-report	11	3.49 (2.45 to 4.98)	<0.001	0.01	0.38	0.12
Psychological autopsy						
No	16	3.53 (2.63 to 4.73)	<0.001			
Yes	3	1.64 (0.90 to 2.99)	0.13	<0.001	0.38	0.03
Study design						
Case-control	10	2.74 (2.04 to 3.69)	<0.001			
Cohort	7	2.69 (1.82 to 3.99)	<0.001			
Cross-sectional	2	8.23 (4.70 to 14.30)	<0.001	0.01	0.73	0.02
Study quality						
Good	7	3.74 (2.20 to 6.30)	<0.001			
Fair	9	2.95 (1.93 to 4.50)	<0.001			
Poor	3	2.18 (1.10 to 4.32)	0.02	0.02	0.18	0.48

ANOVA, analysis of variance.

Exposure to suicidal behaviour. Across 10 effect sizes from 5 independent studies, exposure to suicidal behaviour (composite measure-suicide or suicide attempt) was associated with 2.58-fold (95% CI = 1.25 to 5.35, $P = 0.01$) increased odds of suicidal behaviour (**Figure 3.4**). Heterogeneity within and between studies was comparable ($\tau^2_{(2)} = 0.283$, $I^2_{(2)} = 38\%$; $\tau^2_{(3)} = 0.40$, $I^2_{(3)} = 53\%$). Visual inspection of the funnel plot did not reveal evidence of small study effect (**Figure S3.7**). However, a formal test of asymmetry was not conducted due to insufficient studies. Results from the subgroup analysis revealed that exposure to suicidal behaviour was associated with greater odds of suicide ($k = 7$, OR = 3.83, 95% CI = 2.38 to 6.17, $P < 0.001$) but not suicide attempt ($k = 3$, OR = 1.10, 95% CI = 0.69 to 1.76, $P = 0.90$; Q between subgroups = 5.02, $df = 1$, $P = 0.02$, $R^2_{(2)} = 31.6\%$, $R^2_{(3)} = 100\%$). The odds of suicidal behaviour were also greater when the exposure occurred in relatives ($k = 8$, OR = 3.09, 95% CI = 1.53 to 6.26, $P = 0.001$) compared to friends and acquaintances ($k = 2$, OR = 1.33, 95% CI = 0.69 to 2.92, $P = 0.48$; Q between subgroups = 5.20, $df = 1$, $P = 0.02$, $R^2_{(2)} = 86.2\%$, $R^2_{(3)} = 0\%$). No significant differences were observed for the remaining moderators (**Table 3.5**).

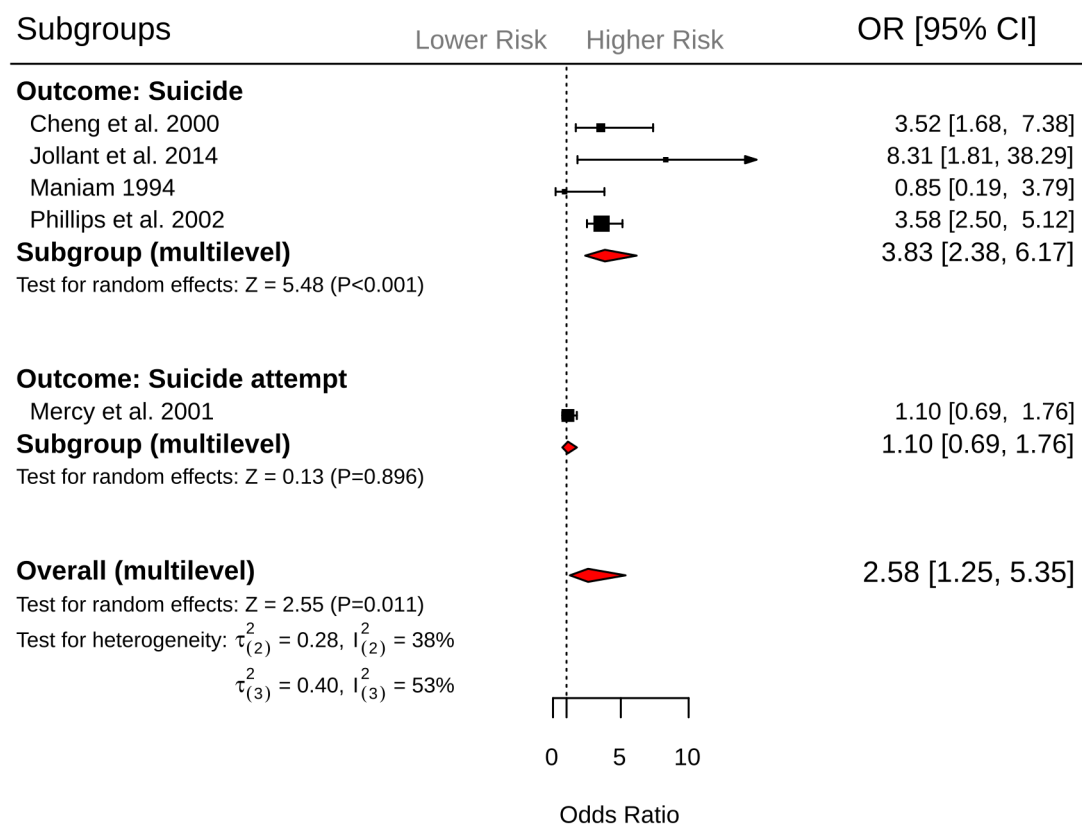


Figure 3.4 Forest plots of exposure to composite measures of suicidal behaviour and subsequent suicide and suicide attempt outcomes. CI = Confidence intervals. OR = Odds ratio.

Table 3.4 Results of moderator analyses of composite measures of suicidal behaviour across suicide, suicide attempt and suicidal ideation outcomes

Moderator	Number of effect sizes	Odds ratio (95% confidence interval)	<i>P</i> value	$R^2_{(2)}$	$R^2_{(3)}$	ANOVA between-group <i>P</i> value
Proximity						
Relative	8	3.09 (1.53 to 6.26)	0.001			
Friend or acquaintance	2	1.33 (0.60 to 2.92)	0.48	0.86	<0.001	0.02
Population at risk						
Adult	4	2.63 (0.96 to 7.22)	0.06			
Youth	6	2.53 (0.86 to 7.43)	0.09	<0.001	0.01	0.96
Outcome measurement						
Informant interview	3	8.34 (2.35 to 29.63)	0.01			
Official records	7	1.90 (1.03 to 3.50)	0.05	<0.01	0.70	0.07
Exposure measurement						
Informant interview	7	3.83 (2.37 to 6.19)	<0.001			
Self-report	3	1.04 (0.59 to 1.83)	0.89	0.32	1	0.02
Psychological autopsy						
No	3	1.04 (0.59 to 1.83)	0.89			
Yes	7	3.83 (2.37 to 6.19)	<0.001	0.32	1	0.02
Study quality						
Fair	3	1.04 (0.59 to 1.83)	0.89			
Poor	7	3.83 (2.37 to 6.19)	<0.001	0.32	1	0.02

3.3 Discussion

Based on findings from 34 studies of mostly good and fair quality, encompassing 13,923,029 participants and 71 effect sizes, we found that prior exposure to suicide was associated with significantly greater odds of suicidal behaviour (suicide or suicide attempt; OR = 2.94). Results of the moderator analysis revealed that prior exposure to suicide was associated with 3.23-fold increased odds of suicide and 2.91-fold increased odds of suicide attempt, while there was no evidence of an association between exposure to suicide and subsequent suicidal ideation. These findings remained robust across cohort, case-control, and cross-sectional studies, as well as exposure and outcome measurements encompassing informant interview, self-report, and official records (e.g., coroner reports, hospital admission records, or data linkage with birth and death registries).

Exposure to suicide attempt was associated with increased odds of suicidal behaviour (OR = 2.99). However, moderator analyses revealed that the association of exposure to suicide attempt with suicide-related outcomes was significant only for suicide attempt (OR = 3.53), not for suicide death (OR = 1.64). These findings were demonstrated across 19 effect sizes from 13 studies of mostly fair quality and corroborated by 3 large population-based studies using data linkage or hospital admission records for suicide attempt^{48, 59, 62}. Exposure to suicidal behaviour (suicide or suicide attempt) was associated with a 2.58-fold increased odds of suicidal behaviour, but moderator analysis revealed that this was significant only for outcomes relating to suicide death (OR = 3.83), not suicide attempt (OR = 1.10). These findings were demonstrated across 10 effect sizes from 5 studies, the majority of which involved psychological autopsy methodologies.

Our analyses update and further specify the findings from previous systematic reviews, which included estimates from studies reporting lifetime prevalence or did not differentiate between the independent effects associated with exposure to suicide and exposure to suicide attempt^{19, 22, 23}. The finding that exposure to suicide was associated with an increased odds of suicide and suicide attempt- in contrast to exposure to suicide attempt, which was associated with an increased odds of suicide attempt only- indicates that exposure to suicide and suicide attempt do not incur uniform risk across the range of suicide-related outcomes. This was corroborated by our analysis of exposure to suicidal behaviour, which found that this composite measure was associated with increased odds of suicide but not suicide attempt, a finding that was inconsistent with our separate analyses of exposure to suicide and exposure to suicide attempt. Taken together, the present findings raise questions about the conceptual value of combining suicide and suicide attempt as a composite measure of suicidal behaviour and suggest that future research and public health policies should refrain from combining these exposures and outcomes into 1 composite measure of suicidal behaviour.

Evidence from 2 studies^{46, 57} suggests that exposure to suicide may be associated with increased risk of suicidal ideation, especially in older adults⁴⁶. Conversely, results from a single cohort study in youths⁵⁷ indicate higher risk for suicide attempt than for suicidal ideation, pointing once more to lack of uniformity across populations and outcomes. Moreover, theoretical and empirical accounts suggest that while exposure to suicide may contribute to subsequent suicidal ideation to some extent, its effect on people with a history of suicidal ideation may be more pronounced⁷², as this experience might reduce cognitive and practical barriers to acting on one's suicidal thoughts^{46, 73, 74}. A more comprehensive look at this interaction may have important practical implications

for developing specific interventions for this high-risk population, in particular interventions guided by the “ideation-to-action framework”⁷² that aim to reduce acquired capability for suicidal behaviour among individuals exposed to suicide.

The increased risks associated with exposure to suicide for outcomes relating to suicide and suicide attempt in the current meta-analyses suggest that further consideration should be given towards developing interventions that target suicide-related outcomes in those bereaved by suicide. To date, interventions targeting those exposed to suicide have largely focused on bereavement-related factors such as grief, reduced social support, and stigma^{75, 76}. Although previous studies have shown that these factors are elevated among those bereaved by suicide as opposed to other modes of death, there remains a dearth of studies that investigate the effectiveness of interventions on suicide and suicide attempt behaviour. A recent review by Andriessen and colleagues⁷⁵, for example, found 3 controlled studies⁷⁷⁻⁷⁹ that investigated the effectiveness of an intervention on suicidal ideation and found no studies that included outcomes related to suicide or suicide attempt.

Although we did not observe a significant association between exposure to suicide attempt and subsequent suicide, the specific relationship between exposure to suicide attempt and subsequent suicide attempt is noteworthy, since suicide attempt is associated with significant disruptions to an individual’s milieu and has been linked to adverse psychosocial and mental health stressors that persist later in life⁵. The findings from our analysis of exposure to suicide attempt also provide some insight into the mechanisms underlying the observed association between exposure to suicide and exposure to suicide attempt and the suicide-related outcomes. Arguably, the absence of bereavement-related factors and the specific association between exposure to suicide

attempt and subsequent suicide attempt support the hypothesis that suicidal individuals may model, or imitate, suicide-related behaviour that they see in others¹⁰. An imitation model is consistent with previous studies that have shown that increased risk of suicide-related behaviour following exposure to both suicide and suicide attempt is not significantly moderated by preexisting risk factors such as depression, anxiety, and hospital admission for mental health^{80, 81}. The finding that exposure to suicide is associated with significant increased odds of suicide attempt is important since public health approaches for the prevention of behavioural contagion of both suicide and suicide attempt, such as frameworks for the prevention of suicide and self-harm clusters¹²⁻¹⁵, have focused largely on mitigation efforts following exposure to suicide and therefore may benefit from the inclusion of exposure to suicide attempt in future mitigation efforts.

3.3.1 Limitations

The current systematic review and meta-analysis is the first to our knowledge to quantify the association between exposure to suicide and suicide attempt and the full spectrum of suicide-related outcomes and has many strengths, including the use of multilevel meta-analysis, the large sample size, and the exclusion of estimates of lifetime prevalence that do not take into account the temporal sequence between exposure and suicide-related outcomes. Despite this, several limitations exist. Whilst we conducted an extensive search of 21,868 records, there is the possibility that some relevant studies were not detected. Such studies are likely to create a bias towards the null (i.e., the exposure not having a significant effect). This is a limitation that is common to many systematic reviews and was mitigated to the best of our ability through adherence to a screening protocol developed a priori.

Furthermore, since most studies adjusted for different covariates, we restricted our analysis to unadjusted events and ORs. Whilst this is consistent with previous meta-analyses in the field^{82, 83}, it meant that we could not investigate other risk factors, such as frequency of exposure, duration since exposure, and baseline mental health diagnoses, and how these might moderate the association between exposure to suicide and suicide attempt and suicide-related outcomes. For example, a previous systematic review on pre- and post-loss features of suicide bereavement in young people found evidence of a cumulative effect of exposure to suicide on subsequent suicide risk⁸⁴. In the present meta-analysis, 2 out of 34 studies included in our analyses provided separate estimates for multiple exposures to suicide⁶² and suicide attempt⁴⁸. In 1 study⁶², exposure to 2 or more suicide deaths affected less than 1% of the population, but was associated with 9.8-fold greater odds of suicide attempt, compared to an OR of 3.8 among those who had been exposed to the suicide of 1 relative. Similarly, those exposed to the suicide attempt of 2 parents were 5.67 times more likely to make a suicide attempt, compared to ORs of 2.89 and 3.89 (for paternal and maternal exposures, respectively) among youths who had been exposed to the suicide attempt of 1 parent⁴⁸.

Indeed, in the present multilevel meta-analysis, within-study heterogeneity remained largely unchanged by study-level moderators for both exposure to suicide and exposure to suicide attempt. For example, we did not find evidence of a significant difference in suicide-related outcomes when the exposure to suicide or suicide attempt occurred in relatives compared to friends and acquaintances. Although previous registry-based studies have shown a 6-fold increase of suicide among biological relatives of adoptees who have died by suicide⁸⁵, in the present meta-analysis it was not possible to delineate

between relatives who resided in the same household, and therefore shared many of the same environmental risk factors, and relatives who did not⁹. Understanding these factors is important for identifying specifically who within in the general population is most at risk. However, the pooling of observational studies meant that analyses of these factors were outside the scope of the present study. An important next step forward would therefore be examinations of exposure to suicide and suicide attempt while taking these risk factors into account using individual participant data meta-analyses.

In the present multilevel meta-analysis, between-study heterogeneity remained moderate ($I^2_{(3)} = 52.2\%$) across studies measuring exposure to suicide, which was not sufficiently explained by any of the included study design moderators. By contrast, study design characteristics accounted for 72.8% of between-study heterogeneity ($I^2_{(3)} = 87.8\%$) across studies measuring exposure to suicide attempt. In this instance, cross-sectional studies reported significantly larger ORs (OR = 8.23) compared to case-control (OR = 2.74) and cohort (OR = 2.69) studies. In general, cross-sectional studies are prone to an inherently greater number of biases, compared to case-control and cohort studies. This may be particularly pronounced in studies that measure suicide attempt because recall of suicide attempt may be less salient than recall of suicide death, and is prone to multiple interpretations and definitions⁸⁶.

It is noteworthy that we did not find evidence to support the role of age as a risk moderator, as suggested in previous reviews^{9, 10}. Yet these results should be interpreted with caution, as the dichotomization of study populations into the categories of youths and adults was based on a majority rule in 13 out of 34 studies^{26-28, 39, 45, 58, 60, 61, 63-65, 68-70}. The finding that age was not a risk moderator may therefore be an artifact introduced by the imprecise age classification of the included population in individual studies.

Furthermore, whilst similar patterns were observed across studies examining exposure to suicide attempt in youths versus adults, only 1 out of 13 studies⁷⁰ reported outcomes among adults, which may have impacted our ability to detect a statistically significant difference.

Finally, the results of the present study do not allow causality to be inferred, and although we show evidence of a temporal association between prior exposure to suicide and suicide attempt and subsequent suicide-related outcomes, cross-sectional studies, by virtue of study design, do not provide incidence estimates. To account for this limitation, we only included cross-sectional studies where participants were explicitly asked about suicidal acts that occurred after exposure to suicide or suicide attempt. But this approach does not mitigate errors in recall and other biases that are inherently more common in cross-sectional studies.

3.3.2 Conclusions

Our findings suggest that prior exposure to suicide is associated with increased risk of suicide and suicide attempt. By contrast, exposure to suicide attempt is associated with increased risk of suicide attempt, but not suicide death. Future studies should carefully consider the potentially confounding effects that arise from combining suicidal behaviours into composite measures of suicide exposures and outcomes particularly with regards to studies involving suicide contagion, as the relationships between exposure to suicide and subsequent suicide, suicide attempt and suicide-related outcomes have markedly different public health implications. Lastly, future studies should consider interventions that target suicide-related outcomes in those exposed to suicide and include efforts to mitigate the adverse effects associated with exposure to suicide attempt.

3.4 References

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3.5 Chapter 3: Supplementary material

Table S3.5 Description of a priori study moderators

1 Suicidal-related behaviour outcome		
Suicide		Self-inflicted injury resulting in death.
Suicide attempt		Self-inflicted injury, or poisoning, with explicit or implied intent to die
Suicidal ideation		Thoughts of suicide
2 Age of the exposed population		
Youth		The population was ≤ 25 years old, or more than 50% of the population was aged ≤ 25 years old.
Adult		The population was > 25 years old, or more than 50% of the population was > 25 years old.
3 Relationship between those exposed and the individual(s) who engaged in suicide or suicide attempt		
Relatives		Spouse, parent, offspring, siblings and extended family members as determined by $\leq 50\%$ of the study population
Friends and acquaintances		Friends, peers, school mates, acquaintances as determined by $\leq 50\%$ of the study population.
4 Risk of bias		
Poor		Exposure and outcome measures were not defined, evidence or information or selection biases.
Fair		Exposure and outcome measures were defined but some evidence of selection or information biases.
Good		Exposure and outcome measures and definitions were defined and no clear information or selection biases present.
5 Study location		
Country		The country where the study was conducted.
6 Study design		
Cross-sectional		Participants were selected based on their exposure and outcome status at the same time.
Case-control		Participants were selected based on their outcome status.
Cohort		Participants were selected based on their exposure status and were followed up over time.
7 Exposure measurement		
Self-report		The participant reports prior exposure to suicide or suicide attempt of another.
Informant interviews		A person who knows the participant reports whether the participant in question was exposed to prior suicide or suicide attempt of another (e.g., a parent).
Official records		Prior exposure indicated by hospital records, death records, or data linkage via population registries.
8 Outcome measurement		
Self-report		The participant reports they have made a suicide or suicide attempt.
Official records		Suicide or suicide attempt in the participant is confirmed by official death records, hospital admissions or data linkage via population registries.
9 Year of publication		
Year		The year listed in the reference of the published manuscript.

Text S3.1 Medline search strategy

1. (Suicid* or Self-harm or self-injur* or self-mutilat*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
2. (bereav* or grief* or griev* or mourn* or widow* or expos* or contagio*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
3. (((Suicid* or Self-harm or self-injur* or self-mutilat*) and cluster*) not (ClusterADJanalys* or ClusterADJrandom*)),ab.
4. exp Genetic Predisposition to Disease/
5. Family Characteristics/
6. (Familial or family history or genetic predisposition).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
7. (famil* or relative or friend or surviv* or spous* or Parent or child* or undergraduate or student or school* or sibling).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
8. 1 and 2
9. 4 or 5 or 6
10. 1 and 9
11. 3 or 8 or 10
12. 7 and 11

Table S3.6 Excluded overlapping studies

Overlapping study- excluded from analysis	Reason for exclusion	Included study	Reason for including study
Ahmadi A, Mohammadi R, Schwebel DC, Yeganeh N, Soroush A, Bazargan-Hejazi S. Familial risk factors for self-immolation: A case-control study. <i>Journal of Women's Health</i> . 2009;18(7):1025-1031.	Excluded because it's a sub sample Ahmadi et al. 2015 study a, N= 30 cases; N= 30 controls	Ahmadi A, Mohammadi R, Almasi A, et al. A case-control study of psychosocial risk and protective factors of self-immolation in Iran. <i>Burns</i> . 2015;41(2):386-393. Study a	Author indicated this is the main study with complete sample of N=151 cases and N=302 controls. The study also reports outcomes for both exposure behaviours (suicide and self-harm/attempt) which is not the case in the remaining two studies.
Ahmadi A, Schwebel DC, Bazargan-Hejazi S, Taliee K, Karim H, Mohammadi R. Self-immolation and its adverse life-events risk factors: results from an Iranian population. <i>Journal of injury & violence research</i> . 2015;7(1):13-18.	Excluded because it's a sub sample Ahmadi et al. 2015 study a, N= 30 cases; N= 30 controls	Ahmadi et al. 2015 study a	
Brent DA, Oquendo M, Birmaher B, et al. Familial pathways to early-onset suicide attempt: Risk for suicidal behaviour in offspring of mood-disordered suicide attempters. <i>Archives of General Psychiatry</i> . 2002;59(9):801-807.	Excluded because it's a sub sample Brent et al. 2015. Offspring of parents who attempted suicide, Self-harm/suicide attempt. The sample consisted of N=449 offspring of N=255 pro-bands with history of mood disorders.	Brent DA, Melhem NM, Oquendo M, et al. Familial pathways to early-onset suicide attempt: A 5.6-year prospective study. <i>JAMA Psychiatry</i> . 2015;72(2):160-168.	The sample consisted of 701 offspring of 334 pro-bands with mood disorders. Pro-bands were clinically referred to the Western Psychiatric Institute or the New York State Psychiatric Institute from Jul 1997- Sep 2005, and followed through to June 2012, encompassing a 5.6-year follow-up period.
Melhem NM, Brent DA, Ziegler M, et al. Familial pathways to early-onset suicidal behaviour: Familial and individual antecedents of suicidal behaviour. <i>American Journal of Psychiatry</i> . 2007;164(9):1364-1370.	Excluded because it's a sub sample of Brent et al. 2015. Offspring of parents who attempted suicide, Self-harm/suicide attempt. The sample consisted of N=365 offspring of N=203 pro-bands with a history of mood disorders.	Brent et al. 2015	
Cerel J, Van De Venne JG, Moore MM, Maple MJ, Flaherty C, Brown MM. Veteran exposure to suicide: Prevalence and correlates. <i>Journal of Affective Disorders</i> . 2015;179:82-87.	Excluded because it's a sub sample of Cerel et al. 2016. The sample consisted N=916 people from the general population exposed or unexposed to suicide of a friend or family member.	Cerel J, Maple M, van de Venne J, Moore M, Flaherty C, Brown M. Exposure to suicide in the community: Prevalence and correlates in one U.S. State. <i>Public Health Reports</i> . 2016;131(1):100-107.	The sample consisted of N=1703 people from the general population exposed or unexposed to suicide of a friend or family member.

Garcia-Valencia J, Palacio-Acosta C, Diago J, et al. Adverse life events and suicide: A case-control study of psychological autopsy in Medellin, Colombia. <i>Eventos vitales adversos y suicidio: Un estudio de autopsia psicologica en Medellin, Colombia</i> . 2008;37(1):11-28.	Excluded because it's the same study as Palacio et al. 2007 but published in Spanish	Palacio C, Garcia J, Diago J, et al. Identification of Suicide Risk Factors in Medellin, Colombia: A Case-Control Study of Psychological Autopsy in a Developing Country. <i>Archives of Suicide Research</i> . 2007;11(3):297-308.	Same article but Published in English.
Brent DA, Perper JA, Moritz G, Liotus L, Schweers J, Canobbio R. Major depression or uncomplicated bereavement? A follow-up of youth exposed to suicide. <i>Journal of the American Academy of Child and Adolescent Psychiatry</i> . 1994;33(2):231-239.	Excluded because it's a sub sample of Brent et al. 1996 study from an earlier time point. The sample consisted of N=146 friends of a suicide decedent and N=146 unexposed community controls, followed up at 12-18 months post baseline interview.	Brent DA, Moritz G, Bridge J, Perper J, Canobbio R. Long-term impact of exposure to suicide: A three-year controlled follow-up. <i>Journal of the American Academy of Child and Adolescent Psychiatry</i> . 1996;35(5):646. (study a)	The sample consisted of N=166 friends of adolescent suicide decedents and N=175 unexposed community controls, followed up at 36 months post baseline interview. The sample included initial participants and follow-up with those who refused throughout the trial. The exposure occurred between Dec 1988-March 1991.
Brent DA, Perper JA, Moritz G, et al. Psychiatric impact of the loss of an adolescent sibling to suicide. <i>Journal of Affective Disorders</i> . 1993;28(4):249-256.	Excluded because it's an earlier time point of Brent 1996 study b. The sample consisted of N=25 siblings of N=20 suicide decedents and 25 matched community controls.	Brent DA, Moritz G, Bridge J, Perper J, Canobbio R. The Impact of Adolescent Suicide on Siblings and Parents: A Longitudinal Follow-Up. <i>Suicide and Life-Threatening Behaviour</i> . 1996;26(3):253-259. (study b)	The initial sample consisted of N=25 siblings of N=20 suicide decedents and N=25 matched community controls, followed up at 37.6 months
C. C. Cheng et al., Risk of adolescent offspring's completed suicide increases with prior history of their same-sex parents' death by suicide. <i>Psychol Med</i> 44, 1845-54 (2014).	Excluded because superseded by longer timepoint in Lee et al. 2018 Data linkage study using Taiwan Births and Deaths registry. Exposure: Suicide of parent Outcome: Suicide between 1997-2007	K. Y. Lee et al., Age at Exposure to Parental Suicide and the Subsequent Risk of Suicide in Young People. <i>Crisis: Journal of Crisis Intervention & Suicide</i> 39, 27-36 (2018).	Data linkage study using Taiwan Births and Deaths registry with suicide occurring between 1978-2009
Abrutyn S, Mueller AS. Are Suicidal Behaviours Contagious in Adolescence? Using Longitudinal Data to Examine Suicide Suggestion. <i>American Sociological Review</i> . 2014;79(2):211-227.	Excluded because superseded by longer timepoints in Thompson et al. 2011. National Longitudinal Study of Adolescent Health. Measured subsequent suicidal thoughts and attempts at wave III based on exposure to suicide attempt of family or friend at wave II (7 years earlier).	Thompson MP, Light LS. Examining Gender Differences in Risk Factors for Suicide Attempts Made 1 and 7 Years Later in a Nationally Representative Sample. <i>Journal of Adolescent Health</i> . 2011;48(4):391-397.	National Longitudinal Study of Adolescent Health. Included because it provides outcome measures for each of the exposure subgroups over an equivocal period of time (7 years). Subsequent suicide attempt reported at 7 years follow up (wave III) following exposures reported in wave I or II: 1) Friend completed suicide; 2) Friend attempted suicide; 3) Family completed suicide; 4) Family attempted suicide

Mueller AS, Abrutyn S, Stockton C. Can Social Ties Be Harmful? Examining the Spread of Suicide in Early Adulthood. <i>Sociological Perspectives</i> . 2015;58(2):204-222.	National Longitudinal Study of Adolescent Health. Subsequent suicide attempt reported at wave IV following exposures reported in Wave III (exposure to suicide or suicide attempt in the past 12 months). Data was not entered because the length of follow-up between measured exposure and outcome was equivocal to Thompson 2011, and the authors combined subgroups (friend and family) and exposure behaviour (suicide and suicide attempt) into one outcome.	Thompson et al. 2011	
Hill RM, Oosterhoff B, Kaplow JB. Prospective identification of adolescent suicide ideation using classification tree analysis: Models for community-based screening. <i>Journal of Consulting and Clinical Psychology</i> . 2017;85(7):702.	National Longitudinal Study of Adolescent Health. Data from wave I & II (1 year follow-up) Data not entered due to limited follow-up period.	Thompson et al. 2011	
Randall JR, Nickel NC, Colman I. Contagion from peer suicidal behaviour in a representative sample of American adolescents. <i>Journal of Affective Disorders</i> . 2015;186:219-225.	National Longitudinal Study of Adolescent Health. Data from wave I & II (1 year follow-up). Data not entered due to limited follow-up period.	Thompson et al. 2011	
Mueller AS, Abrutyn S. Suicidal disclosures among friends: using social network data to understand suicide contagion. <i>Journal of Health & Social Behaviour</i> . 2015;56(1):131-148.	National Longitudinal Study of Adolescent Health. Data from wave I & II (1 year follow-up). Data not entered due to limited follow-up period.	Thompson et al. 2011	
Nanayakkara S, Misch D, Chang L, Henry D. Depression and exposure to suicide predict suicide attempt. <i>Depression and Anxiety</i> . 2013;30(10):991-996.	National Longitudinal Study of Adolescent Health. Data from wave I & II (1-year follow-up). Data not entered due to limited follow-up period.	Thompson et al. 2011	

Ali MM, Dwyer DS, Rizzo JA. The social contagion effect of suicidal behaviour in adolescents: Does it really exist? <i>Journal of Mental Health Policy and Economics</i> . 2011;14(1):3-12.	National Longitudinal Study of Adolescent Health. Data from wave I & II (1-year follow-up)	Thompson et al. 2011	
Zamora-Kapoor A, Nelson LA, Barbosa-Leiker C, Comtois KA, Walker LR, Buchwald DS. Suicidal ideation in American Indian/Alaska Native and White adolescents: The role of social isolation, exposure to suicide, and overweight. <i>American Indian and Alaska native mental health research (Online)</i> . 2016;23(4):86-100.	National Longitudinal Study of Adolescent Health. Data from wave I (baseline).	Thompson et al. 2011	
Cerel J, Roberts TA. Suicidal behaviour in the family and adolescent risk behaviour. <i>Journal of Adolescent Health</i> . 2005;36(4):352.	National Longitudinal Study of Adolescent Health. Data from wave I (baseline)	Thompson et al. 2011	
Cerel J, Roberts TA, Nilsen WJ. Peer suicidal behaviour and adolescent risk behaviour. <i>Journal of Nervous and Mental Disease</i> . 2005;193(4):237-243.	National Longitudinal Study of Adolescent Health. Data from wave I (baseline).	Thompson et al. 2011	
R. X. Liu, Vulnerability to Friends' Suicide Influence: The Moderating Effects of Gender and Adolescent Depression. <i>Journal of Youth and Adolescence</i> 35, 454 (2006).	National Longitudinal Study of Adolescent Health. Data from wave I (baseline).	Thompson et al. 2011	
M. Asberg et al., Family history of suicide among suicide victims. <i>American Journal of Psychiatry</i> 160, 1525-6 (2003).	Sweden population registry-based study Exposure: Suicide in relatives Outcome: Suicide between 1963-1997 N=62,118	Tidemalm, D., Runeson, B., Waern, M., Frisell, T., Carlstrom, E., Lichtenstein, P. & Langstrom, N. Familial clustering of suicide risk: a total population study of 11.4 million individuals', <i>Psychological Medicine</i> . 2011; 41 (12), 2527-34.	Sweden population registry-based study. Broad definition of relative and encompassing all suicide deaths during the study period. Exposure: Suicide in relatives Outcome: Suicide between 1957-2003 N=7,969,645 (suicide=83,951)
E. Rubenowitz et al., Life events and psychosocial factors in elderly suicides--a case-control study. <i>Psychological medicine</i> 31, 1193-202 (2001).	Psychological autopsy study but cases identified from the population register in Sweden. Exposure: Suicide in relatives Outcome: Suicide between 1994-1996 N=238	Tidemalm et al. 2012	

M. B. Guldin et al., Incidence of suicide among persons who had a parent who died during their childhood a population-based cohort study. <i>JAMA Psychiatry</i> 72, 1227-34 (2015).	Population-based study based on three Scandinavian countries. Sweden, Denmark, Norway and specific to childhood exposure.	Tidemalm et al. 2013	
Agerbo E. Risk of suicide and spouse's psychiatric illness or suicide: nested case-control study. <i>British Medical Journal</i> . 2003;327(7422):1025-1026.	Denmark population registry-based study. Exposure: Suicide of spouse/relative Outcome: Suicide between 1982- 1997 N=300,403 (suicide =9011)	Agerbo E, Mortensen PB, Qin P. Suicide risk in relation to socioeconomic, demographic, psychiatric, and familial factors: a national register-based study of all suicides in Denmark, 1981-1997. <i>American Journal of Psychiatry</i> . 2003;160(4):765-772.	Denmark population registry-based study. Broad definition of relative and encompassing all suicide deaths during the study period. Exposure: Suicide of relative Outcome: Suicide between 1981-1997 N=444,297 (suicide=21,169)
Qin P, Mortensen PB. The impact of parental status on the risk of completed suicide. <i>Archives of general psychiatry</i> . 2003;60(8):797-802.	Denmark population registry-based study. Exposure: Suicide of parent Outcome: Suicide between 1981-1997 N=390,831 (suicide=18611)	Agerbo et al. 2003	
Qin, P., Agerbo, E., & Mortensen, P. B. (2002). Suicide risk in relation to family history of completed suicide and psychiatric disorders: a nested case-control study based on longitudinal registers. <i>Lancet</i> , 12, 1126-1130.	Denmark population registry-based study. Exposure: Suicide relative Outcome: Suicide between 1981-1997 N=253,679 (suicide=12897)	Agerbo et al. 2003	
Agerbo E, Nordentoft M, Mortensen PB. Familial, psychiatric, and socioeconomic risk factors for suicide in young people: Nested case-control study. <i>British Medical Journal</i> . 2002;325(7355):74.	Denmark population registry-based study. Exposure: Suicide of sibling Outcome: Suicide between 1981-1997 N=25,296	Agerbo et al. 2003	
Sorensen HJ, Mortensen EL, Wang AG, Juel K, Silvertown L, Mednick SA. Suicide and mental illness in parents and risk of suicide in offspring: a birth cohort study. <i>Social psychiatry and psychiatric epidemiology</i> . 2009;44(9):748-751.	The Copenhagen Perinatal Cohort. Suicide cases identified from Denmark population registry system. Exposure: Suicide of parent Outcome: Suicide between 1969-1996 N= 7,279	Agerbo et al. 2003	

Petersen L, Sorensen TIA, Andersen PK, Mortensen PB, Hawton K. Genetic and familial environmental effects on suicide attempts: A study of Danish adoptees and their biological and adoptive siblings. <i>Journal of Affective Disorders</i> . 2014;155:273-277.	Denmark population registry-based study. Exposure: Suicide of sibling Outcome: Suicide between 1977-2010 N=3,202	Agerbo et al. 2003	
L. Petersen et al., Genetic and familial environmental effects on suicide--an adoption study of siblings. PloS one 8, e77973 (2013).	Denmark population registry-based study.Exposure: Suicide of adopted siblingOutcome: Suicide between date of adoption to 2009 N= 6,172	Agerbo et al. 2003	

Table S3.7 Risk of bias- case control studies

Study					Control selection		Participant selection							Exposure measurement						
	Study design	Objective stated	Population defined	Sample size justification	Similar population	Similar timeframe	Consistent	Valid/ reliable	Adequate comparison group	Random selection	Concurrent control	Exposure preceded outcome	Defined	Valid/reliable	Implemented consistently	Assessor blinding	Confounders adjusted	Overall ROB		
Agerbo 2003	Case control	Yes	Yes	No ^b	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Yes	No	Yes	Good		
Ahmadi 2015	Case control	Yes	Yes	No	No	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Yes	No	Yes	Fair		
Chachamovich 2015	Case control	Yes	Yes	No	No ^c	Yes	Yes	Yes	Yes	N/A	No	No	Partial	Partial ^d	Yes	Yes	Yes	Fair		
Christiansen 2011	Case control	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Yes	No	Yes	Good		
Gould 1996	Case control	Yes	Yes	Yes	No ^c	No	Yes	Yes	Yes	N/A	No	Yes	Yes	Partial ^d	Yes	No	Yes	Fair		
Gray 2014	Case control	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Partial ^d	Yes	No	Yes	Fair		
Hu 2017	Case control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Yes	No	Yes	Good		
Palacio 2007	Case control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	No	Partial ^d	Yes	No	Yes	Poor		
Tidemalm 2011	Case control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Yes	No	Yes	Good		
Vijayakumar 1999	Case control	No ^a	No	Yes	No	No	Yes	Yes	Yes	N/A	No	Yes	Yes	Partial ^d	Yes	No	Yes	Fair		
Conner 2007	Case control	No ^a	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Fair		
Foster 1999	Case control	Yes	Yes	No	No ^c	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Partial ^d	Yes	No	Yes	Fair		

Garfinkel 1982	Case control	No ^a	Yes	No	Yes	Yes	NR	No	Yes	N/A	No	Yes	No	NR	Yes	No	No	Poor
Katibeh 2018	Case control	No ^a	No	No	NR	NR	NR	No	No	N/A	No	Yes	Yes	Yes	Yes	No	Yes	Poor
Mittendorfer-Rutz 2008	Case control	Yes	Yes	No ^b	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Yes	Yes	No	Yes	Good
Giupponi 2018	Case control	Yes	Yes	No	No ^c	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Partial ^d	Yes	No	Yes	Fair
Liu 2019	Case control	Yes	Yes	No	No ^c	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	Partial ^d	Yes	No	Yes	Fair
Cheng 2000	Case control	Yes	Yes	Yes	No ^c	Yes	Yes	Yes	Yes	N/A	No	Yes	No	No ^{d,e}	Yes	No	Yes	Poor
Jollant 2014	Case control	Yes	Yes	Yes	No	No	Yes	Yes	Yes	N/A	No	No	Yes	No ^{d,e}	No	No	No	Poor
Mercy 2001	Case control	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	N/A	No	Yes	Yes	No ^c	Yes	No	Yes	Fair
Maniam 1994	Case control	Yes	Yes	Yes	No ^c	NR	Yes	Yes	Yes	N/A	No	Yes	No	No ^{d,e}	Yes	No	No	Poor
Phillips 2002	Case control	No ^a	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No ^{d,e}	Yes	No	Yes	Poor

NR-Not reported

^aExploratory study

^bPopulation-based study

^cLiving control

^dPsychological autopsy

^eExposure to suicidal behaviour composite

Table S3.8 Risk of bias- cross-sectional and cohort studies

Study	Study design	Objective stated	Population defined	Participation $\geq 50\%$	Subject recruitment			Variance and effect estimates provided	Exposure preceded outcome	Sufficient timeframe	Measured levels of exposure	Exposure measurement				Outcome measurement						
					Similar population	Similar timeframe	Consistent					Defined	Valid/reliable	Implemented consistently	Assessed more than once	Defined	Valid/reliable	Implemented consistently	Assessor blinded	Follow-up $\leq 20\%$	Confounders adjusted	Overall ROB
Almeida 2012	Cross-sec	Yes	Yes	Yes	Yes	yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	N/A	Yes	Good
Brent 1996 study a	Cohort	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Good
Brent 1996 study b	Cohort	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Good
Brent 2015	Cross-sec	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	N/A	Yes	Good
Gravseth 2010	Cohort	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Good
Nrugham 2007	Cross-sec	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No	Partial	Yes	No	N/A	Yes	Poor
Swanson 2013	Cohort	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Fair
Thompson 2011	Cohort	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Partial	Partial	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Fair
Lewinsohn 1994	Cohort	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Good
Chan 2018	Cross-sec	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Partial	Partial	Yes	No	Yes	Partial	Yes	No	Yes	Yes	Fair
Hishinuma 2018	Cohort	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Fair
Lee 2018	Cohort	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Good

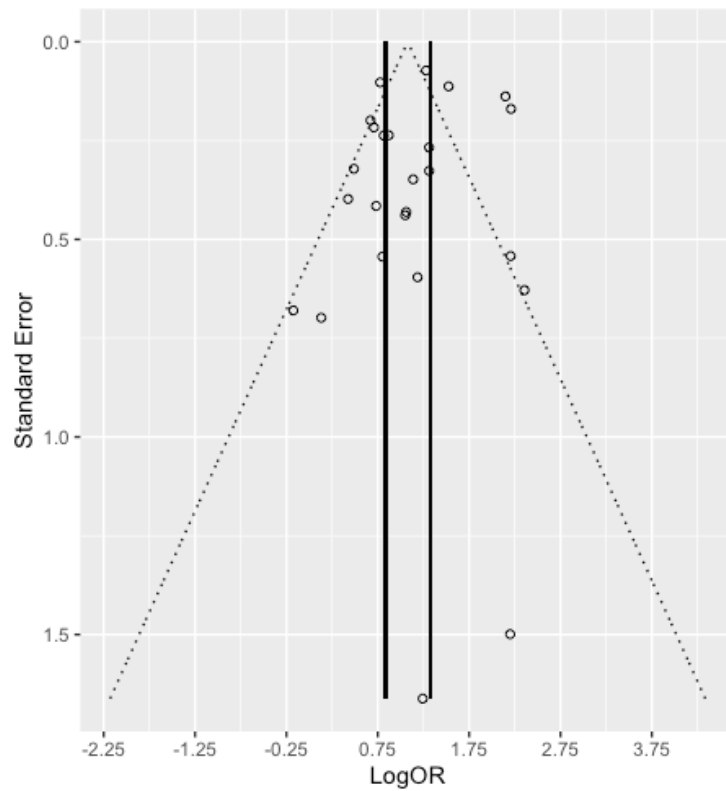


Figure S3.5 Exposure to suicide funnel plot. The solid vertical lines indicate the 95% confidence interval around the log odds ratio (LogOR). The dashed lines indicate the summary log odds ratio $\pm 1.96 \times$ standard error for each of the standard errors on the y-axis. The resulting triangular region indicates the expected location of 95% of studies in the absence of small study effect.

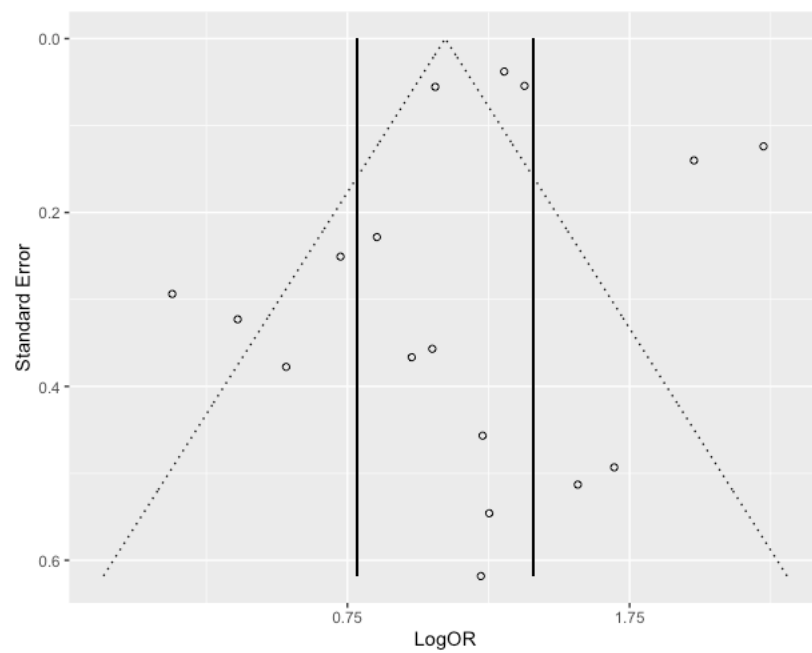


Figure S3.6 Exposure to suicide attempt funnel plot. The solid vertical lines indicate the 95% confidence interval around the log odds ratio (LogOR). The dashed lines indicate the summary log odds ratio $\pm 1.96 \times$ standard error for each of the standard errors on the y-axis. The resulting triangular region indicates the expected location of 95% of studies in the absence of small study effect.

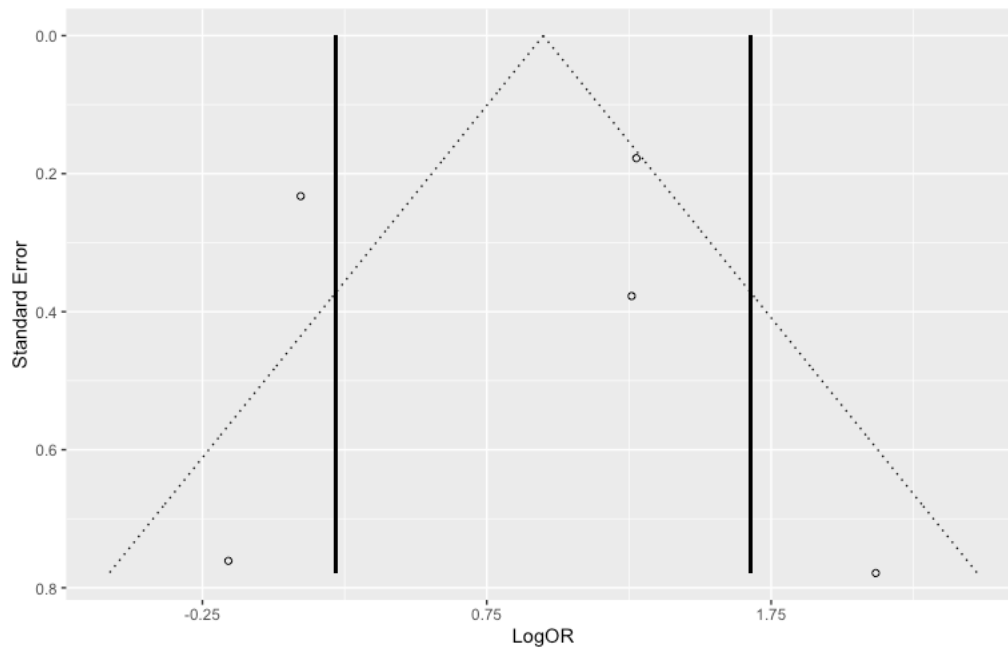


Figure 3.7 Exposure to suicidal behaviour funnel plot. The solid vertical lines indicate the 95% confidence interval around the log odds ratio (LogOR). The dashed lines indicate the summary log odds ratio $\pm 1.96 \times$ standard error for each of the standard errors on the y-axis. The resulting triangular region indicates the expected location of 95% of studies in the absence of small study effect.

Text S3.2 Excluded articles

Not exposed to suicidal behaviour (Suicide attempt/self-harm or suicide death)

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Chapter 4: Risk factors associated with suicide clusters in Australian youth: identifying who is at risk and the mechanisms associated with cluster membership

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Abstract

Background: Young people who have been exposed to suicide have an increased risk of being involved in a suicide cluster. However, it is unclear whether suicide clusters are influenced by the social transmission of suicidal behaviour (i.e., suicide contagion) or a consequence of homophily among young people with common pre-existing risk factors (i.e., assortative relating).

Methods: Suicide clusters involving two or more suicides occurring among young people who shared social links were defined through Australia's National Coronial Information System (NCIS). The duration of survival among exposed cases were estimated using time to event methods. Evidence of assortative relating and/or imitative suicide were estimated by examining the casewise concordance of demographic, social and clinical characteristics among index and exposed cases.

Results: We identified links between 117 young people (69 pairs; 51 suicide clusters). More than half of linked cases lived within 10km of one another and half of exposed cases died within 90 days of the index suicide. Individuals exposed to railway suicide had an 80% probability of dying by the same method and those exposed to the suicide

of a person aged 10-18 years had an 86% probability of being from the same age group. For those residing in remote communities and those of Aboriginal and Torres Strait Islander descent the probabilities of exposed cases sharing these characteristics in common with the index case were 57% and 60%, respectively.

Conclusion: The present study provides evidence of both the social transmission of suicidal behaviour and assortative relating among cluster members. Individuals who have detailed knowledge of the circumstances of death are at risk of imitative suicide should be included in screening efforts and when necessary be provided with access to postvention support.

4.1 Introduction

Suicide is the second leading cause of death in young people aged 10-24 years, worldwide and accounts for approximately 150,000 preventable deaths in young people under the age of 25, each year¹. An individual's risk of suicide increases sharply during adolescence, as does the risk of being involved in a suicide cluster^{2,3}. Population-based studies that define a suicide cluster in terms of a greater than expected number of suicides, occurring within a particular time and place, have shown that young people are two to four times more likely to be involved in a suicide cluster, relative to adults aged 25 years and above^{4,5}.

Studies of suicide clusters in community settings typically characterise suicide clusters on the basis of shared social links between two or more suicides in specific settings such as schools, inpatient units, and remote communities^{6,7}. Clusters of this nature have been linked to prior exposure to suicide, a known risk factor for later suicide⁸, and can lead to widespread speculation about the antecedents and circumstances of the deaths^{9,10}, prolonged grief¹¹ and heightened fear and anxiety among members of the community of the prospect of future suicides^{2,9}. Together, these factors have been associated with further suicides in the community and have led to the development of cluster response guidelines¹²⁻¹⁴ as well as sentinel surveillance systems for the detection of both self-harm and suicide clusters¹⁵.

Multiple mechanisms have been put forth to explain how exposure to suicide may influence subsequent suicidal behaviour in others including social learning—the notion that young people learn from and model the behaviour they see in others; and descriptive norms, which describes the process where individuals are more likely to endorse suicidal behaviour as an acceptable option when they perceive it to be common^{16,17}. Examples of the association between the social transmission of suicidal behaviour and suicide clusters has been reported following sensationalist newspaper reports of suicide¹⁸, and following memorials (including

those online) which glorified the deceased^{9,10}. Social integration and regulation describes the influence that social structures and expectations have on an individual's behaviour and may be influenced by both exposure to suicide and the presence of pre-existing risk factors^{17,24,25}. For example, in highly integrated communities, individuals who perceive themselves as different to may be particularly susceptible to suicide. Additionally, the close social ties among members of a highly integrated community may facilitate the spread of information about suicide to vulnerable members of the community²⁵.

Another theoretical model, known as assortative relating, is based on the premise that individuals who are vulnerable to suicide may already cluster together according to pre-existing characteristics (or risk factors) such as adverse mental health or history of self-harm¹⁹. According to an assortative relating model, suicide clusters may emerge in response to simultaneous exposure to external pressures or stressful events among vulnerable peer groups¹⁹. An assortative relating hypothesis appears consistent with previous studies that have shown that young people tend to associate with peers who share similar risk factors such including levels of depression²⁰ and aggression²¹ and is consistent with previous case-control studies of suicide clusters that report higher rates of prior substance misuse²², self-harm behaviours²², and pre-existing mental ill health^{22,23} among young people involved in a suicide cluster, relative to living controls.

Systematic reviews examining the mechanisms of suicide clusters have suggested that both the social transmission of suicidal behaviour and assortative relating may operate to varying extents for suicide clusters in different communities^{2,6}. However, direct comparisons of the mechanisms underlying suicide clusters have not yet been conducted using data from national suicide mortality registries. Together, the ecological design of many nationwide, population-based studies of suicide clusters means that it is not possible to determine whether members of a suicide cluster were exposed to suicide to one another, nor the extent to which members

of a suicide cluster shared similar demographic, social, and clinical risk factors; both of which are critical for identifying who is at risk and identifying what mechanisms might be operating during a suicide cluster.

Identifying the risk factors and mechanisms that are associated with suicide clusters has the potential to better identify who is at risk of being involved in a suicide cluster and inform the development of targeted interventions designed to avert further suicide deaths. This is particularly important given recent evidence which suggests that the social links between cluster members differ significantly between different cluster events— suggesting that some, but not all suicide clusters, involve social links between cluster members²⁶. Arguably, suicide clusters that are facilitated by the social transmission of suicidal behaviour may warrant different preventative approaches (e.g., strategies to prevent the spread of potentially harmful information such as the methods of suicide) than those which are associated with pre-existing risk factors (e.g., those which may be better address by upscaling or improving access to mental health services).

This study aimed to compare the demographic, social and clinical characteristics of pairs of young people in Australian suicide clusters and the circumstances of their deaths, in order to describe the risk factors associated with suicide clusters and to identify important characteristics of suicide clusters (e.g., the duration of risk associated with cluster membership). Additionally, we sought to identify the mechanisms underlying suicide clusters. We assumed that if assortative relating was operating, then the pairs of young people would share characteristics in common, and that if the social transmission of suicidal behaviour was operating then the circumstances surrounding their deaths would be similar.

4.2 Method

4.2.1 Sample and case ascertainment

We conducted a retrospective cross-sectional analysis of young people who had died in a suicide cluster in Australia between 2006 and 2015 based on data recorded in the National Coronial Information System (NCIS). The NCIS is an online data storage and retrieval system that is used to monitor external causes of death in Australia^{27,28}. Each case recorded in the NCIS includes a core data set that comprises basic demographic information (e.g., age, sex, Aboriginal and Torres Strait Islander status, employment status, student status, residential remoteness). Additional information on the circumstances surrounding each individual's death is available in the form of post-mortem autopsy and toxicology reports, as well as from the narrative text of police and coroner reports. Eligible cases were extracted from the NCIS database (<https://www.ncis.org.au/>) in April 2017 and an updated search for closed cases was conducted in June 2019. Data was extracted directly from narrative text between April 2017 and June 2019.

Suicide clusters were defined as two or more suicides occurring among young people aged 10-24 who shared social links as friends or acquaintances¹³. Definitions of suicide clusters vary widely across individual studies and public health guidelines for the detection, response and prevention of suicide clusters. Although suicide clusters are most commonly described in terms of three or more suicides^{2,6,7}, the most recent public health guidelines for responding to suicide clusters published by Public Health England¹⁴ note that two or more suicides that share social links ought to be taken seriously due to the potential social transmission of suicidal behaviour operating in the community. For this reason, the current study defines a suicide cluster on the basis of two or more individuals that share social links.

A case was eligible for inclusion in the analyses if: 1) the death occurred between 1 January 2006 and 31 December 2015; 2) the individual was aged 24 years or less at the time of death; 3) the case included at least one electronic police or coroner report that provided information on the demographic, social, clinical characteristics as well as the circumstances of death; 5) and the case was closed (fully investigated) by the coroner. We retrieved data on 3665 suicide cases from the NCIS. Of these, 338 cases (including all 245 cases from the state South Australia) were excluded due to the absence of information in the narrative text of police and coroner reports. This resulted in a total of 3027 suicide cases that were assessed for evidence of social links with other young people who had died by suicide.

4.2.2 Links between index and exposed cases

We labelled the first suicide case as the index case and labelled cases that were known to have been exposed to one or more index case as exposed cases. We used the following information to identify linked cases within a suicide cluster: 1) the narrative text referred to the first and last name of the person who previously died by suicide (the index case) or; 2) the narrative text referred to the date of death (e.g., month and year) and described at least one other characteristic that could identify the index case based on information included in the case records (e.g., the name of the school, the address, or the place of employment of the individual who died by suicide). No limits were placed on the duration between index and exposed cases other than that the suicides occurred during the ten-year study period. These cases formed the basis of the study data.

4.2.3 Characteristics and circumstances of death

Demographic, social, and clinical characteristics and the circumstances of death were extracted from the NCIS for each case. These included: age, sex, Aboriginal and Torres Strait Islander status, employment status, student status, residential remoteness, relative

socioeconomic advantage and disadvantage, method of suicide, date of death and location of death. The location of residence, remoteness of residence, and socioeconomic advantage and disadvantage were aggregated at an area level, based on the Australian Statistical Geography Standard Statistical Areal Level 2 (SA2). We calculated the centroid (the geometric centre) of each SA2 and stored these data as longitude and latitude points for each eligible case in the NCIS and calculated the distance between the residence of index and exposed cases.

Information on social and clinical characteristics were extracted by examining the narrative text in electronic police reports, coroner reports, autopsy reports, and toxicological findings using content analyses. Definitions used to identify the presence or absence of each variable are shown in **Table 4.1**. The first author (NTMH) identified characteristics a priori in consultation with the senior author (JR) and extracted these data into a proforma developed for this study.

4.2.4 Data analysis

The distance between index and exposed cases was estimated by calculating the shortest possible distance between SA2 centroids using the geosphere package in R version 3.6.2. The geocode function of the ggmap package was used to identify the centroids and corresponding longitude and latitude geocoordinates of each SA2. Post hoc analyses were conducted to estimate the correlation between distance between index and exposed cases and the duration since exposure.

The duration of risk following exposure to an index suicide was determined using survival analysis. Survival time (defined as the time in days between the date of the suicide of the index case and the date of death of the exposed case) was estimated for each exposed case by subtracting the date of index death from the date of the exposed death. Kaplan-Meier survival curves were drawn using the survival and survminer packages in R 3.6.2.

The average annual percent change based on the date of the index death was calculated for both the number of suicide clusters and the number of cluster members, each year, over the 10 year study period.

The risk factors and characteristics associated with cluster membership was identified using casewise concordance under complete ascertainment²⁹ for the demographic, social and clinical characteristics, and the circumstances of death among index and exposed cases (**Table 4.1**). The casewise concordance is the conditional probability that that if one member of pair has the characteristic of interest, the other also has the same characteristic. In the present study, casewise concordance was defined as the probability that the exposed case had the characteristic of interest (e.g., male sex), given that the index case has the same characteristic. The probabilities are reported as percentages with corresponding 95% confidence intervals.

Due to power limitations, we excluded variables from the casewise concordance analyses if they were recorded in fewer than 5 index and exposed cases. Since any index case or exposed case could be linked to multiple cases (e.g., two exposed cases could be linked to the same index case) and later cases in clusters of three or more suicides could be included as both an index and exposed case (e.g., the second case in a cluster of three suicides might be exposed to the suicide of the first case but may also serve as an index case for the third case within the cluster), the assumption of statistical independence was not met. Therefore, to allow for correlations between index and exposed cases within we adjusted the standard errors for dependency within clusters.

The mechanisms underlying suicide clusters were operationalised by examining the circumstances of death and the demographic, social and clinical risk factors recorded in the NCIS. Specifically, evidence of the social transmission of behaviour was identified by examining the casewise concordance associated with the circumstances of death (**Table 4.1**).

Evidence of assortative relating was operationalised by examining the probability that index and exposed cases shared the same demographic, social and clinical characteristics.

This study received full ethical approvals from the Justice Department Human Research Ethics Committee (CF/15/13188).

Table 4.1 Table of definitions of included variables

Variable	Definition and ascertainment	Variable
Age ^a	Determined by the NCIS core dataset.	Demographic
Sex ^a	Determined by the NCIS core dataset.	Demographic
Aboriginal or Torres Strait Island status ^a	Determined by the NCIS core dataset.	Demographic
Student status ^a	Determined by the NCIS core dataset.	Demographic
Employment status ^a	Determined by the NCIS core dataset.	Demographic
Socioeconomic disadvantage (SEIFA) ^a	Determined by SA2 place of residence. The variable represents people who resided in regions that were identified in the bottom 20th percentile of socioeconomic disadvantage determined by the Australian Bureau of statistics Socio-economic index for advantage and disadvantage based on Statistical Area level 2.	Demographic
Remoteness ^a	Determined by SA2 place of residence. The variable represents people who resided in regions that were identified as remote or very remote in the NCIS.	Demographic
Distance between the residence of index and exposed cases ^a	Based on the geographic centroid of place of residence based on SA2 geography recorded in the NCIS core dataset.	Demographic
Parent separation ^a	Based on informant reports that the person's biological or adoptive parents were divorced or separated at the time of death or otherwise married or living in a de facto relationship. A definition of parent separation includes indirect evidence (e.g., narrative descriptions that indicate the young person lived with their mother).	Social
Living alone ^a	Based on informant reports or other documented evidence (e.g., police observation) that the person lived alone (e.g., the absence of roommates or other cohabitating household members).	Social
History of abuse and/or neglect ^a	Based on an informant report or other documented evidence (e.g., police statements) that the person had been sexually, physically or emotionally abused, or that the person had experienced neglect in their family home. Excludes informant reports of suspected abuse or neglect.	Social

Exposure to domestic violence ^a	Based on an informant report or documented police statements that the person had experienced violent or aggressive behaviour within the home. Includes exposure during childhood to domestic violence between parents.	Social
Relationship breakdown with an intimate partner (past 1 month) ^a	Based on an informant report that the person had a relationship breakdown with an intimate partner. Includes teenage boyfriend/girlfriend relationships and online relationships.	Social
Peer conflict (past 12 months) ^a	Based on an informant report that the person experienced relationship problems (e.g., arguments or physical confrontations) with their peers, or those in their friendship circle, in the 12 months prior to their death.	Social
Family conflict (past 12 months) ^a	Based on an informant report that the person had experienced relationship problems (e.g., arguments or physical confrontations) with their family members. Includes conflicts in the family environment that described the person had feelings that they were not able to meet family expectations.	Social
Diagnosed or undiagnosed mental ill health ^a	Based on documented medical evidence that the young person: 1) had a psychiatric diagnosis prior to their suicide; <i>OR</i> 2) the young person was being treated by a medical practitioner (e.g., GP, psychologist, psychiatrist) for mental-illness; <i>OR</i> 3) an informant reported that the young person was being treated for mental health symptoms <i>AND</i> results from the NCIS toxicology report described the presence of therapeutic levels of psychotropic medication (e.g., antidepressants) at or around the time of death; <i>OR</i> 4) The young person told an informant that they had mental health problems, but it was not otherwise verified by official records during the police or coroner investigation or evidence of therapeutic levels of psychotropic medication in the toxicology findings.	Clinical
Suicide attempt or self-harm (irrespective of intent) ^a	Based on an informant report or documented medical evidence that the person had made a suicide attempt or had self-harmed in the 12 months prior to their suicide. Includes presenting to healthcare services (e.g., Emergency Department) for a suicide attempt, informant descriptions of self-harm or suicide attempts, as well as indirect evidence from autopsy reports (e.g., the autopsy reported evidence of self-inflicted injuries or evidence of healing wounds from self-inflicted injuries such as abrasions to the wrist or consistent with cutting). Does not include informants reports of suspected self-harm or suicide attempt.	Clinical

Discharged from the Emergency Department (ED) for mental-health symptoms ^a	Based on an informant report or documented medical evidence that the person presented to the ED prior to their suicide for reasons primarily related to mental health symptoms (including self-harm) and was discharged from the ED. Excludes presentations to the ED for reasons unrelated to mental health (e.g., suspected appendicitis) or informant reports of ED presentations for reasons unknown (e.g., may or may not have presented to the ED primarily because of mental health symptoms).	Clinical
Illicit substances detected in toxicology report ^a	Based on toxicology findings that indicated the presence of illicit substances (e.g., methamphetamine, cannabis, cocaine, ecstasy and/or their by-products demonstrating recent use of illicit substances. Includes substances of misuse (e.g., taurine from paint, petroleum from petrol).	Clinical
Binge drinking ^a	Based on an informant report that the young person had been drinking excessively in the month prior to their death.	Clinical
Alcohol intoxication ^b	Based on toxicology findings that indicated a blood alcohol concentration >1500 mmol/l. Excludes alcohol readings from urine samples and toxicology reports that indicated that the alcohol concentration was likely to be influenced by post-mortem changes (i.e., decomposition).	Circumstances of suicide
Method of suicide ^b	Determined by coroner report and ICD-10 code for cause of death.	Circumstances of suicide
Suicide note ^b	Based on an informant report or police observation that the person had written a suicide note that indicated their intent to die. Includes goodbye text messages and emails sent by the deceased prior to their suicide.	Circumstances of suicide
Told someone they wanted to die ^b	Based on an informant report that the person expressed suicidal ideation or indicated that they wanted to take their own life or die. Includes written, verbal communication, text communication and email communication.	Circumstances of suicide
Communicated about suicide on social media ^b	Based on an informant report or evidence of online activity that showed the person posted content about suicide or expressed suicidal ideation on social media (e.g., posted a suicide note on Facebook, or shared a post that indicated they were suicidal).	Circumstances of suicide
Searched the internet for suicide methods ^b	Based on the police or coroner report that described evidence of internet queries about suicide or the person had visited a website that described methods of suicide.	Circumstances of suicide
Time of death	Based on the date (dd/mm/yyyy) of death. Date of death was determined by the coroner and recorded in the NCIS core dataset.	Circumstances of suicide

^aincluded in the analysis of assortative relating; ^bincluded in the analysis of imitative suicidal behaviour

4.3 Results

4.3.1 Identification of suicide clusters

Overall, 120 exposed cases (young people who were exposed to the suicide of another young person) were manually inspected for linkage to an index suicide (**Figure 4.1**). Of these, we found social links between 71 (59%) exposed cases that were linked to an additional 46 suicides, resulting 117 index and exposed cases that were included in the analyses. A total of 19 dependencies were identified (Supplementary **Table S4.2**) resulting in 69 linked pairs across 51 suicide clusters. The suicide clusters comprised 40 dyads (N=80 suicides), 7 triads (N=21 suicides) and 4 tetrads (N=16 suicides, appendix table A1). We could not identify reliable links among 49 young people (48%) who were exposed to suicide during the study period. The characteristics of linked and missing cases are presented in (Supplementary **Table S4.3**).

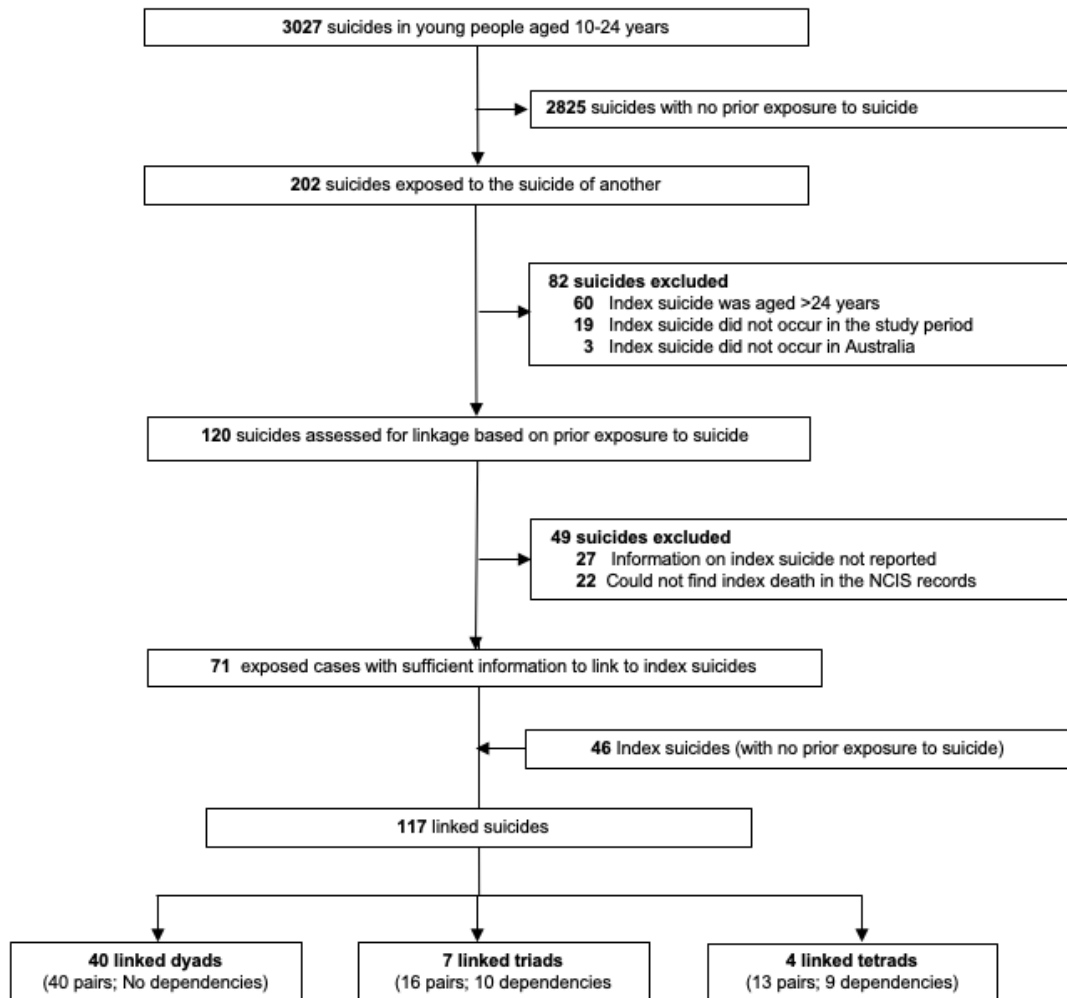


Figure 4.1 Flowchart of suicides and cluster linked cases of young people aged 10-24 years who died by suicide in Australia in 2006-2015.

4.3.2 Characteristics of suicide clusters

The mean age of the 117 young people who died by suicide and could be linked to the suicide of another young person was 18.7 years (SD=3.1, range= 10-24 years). The majority of linked cases were friends and acquaintances (53/69, 77%), and (19/69, 23%) were exposed to both a relative and friend or acquaintance. The demographic, social, and clinical variables as well as the circumstances of death among index and exposed cases are shown in **Table 4. 2**. Overall, 33 (55%) index and exposed cases lived in SA2s that were within a 10km of one another and an additional 19 (37%) lived within 100km. Combined, more than two thirds (75%) of index and exposed cases lived in SA2s that were separated by less than 100kms (**Figure 4.2**). Post hoc analysis of the correlation between distance and time was small and non-significant ($r=0.1$, 95% CI= 0.1 to 0.4) suggesting that individuals did not relocate over longer time periods. **Figure 4.3** shows the number of incident suicide cluster events and cluster members that occurred each year, throughout the study period. Between 2006 and 2015 the number of suicide cluster events increased by an annual average percent change of 50%. Results of the survival analysis revealed that the median duration of survival among exposed cases was 87 days (**Figure 4.4**). In other words, 50% of exposed cases died within 90 days of exposure to an index suicide (range = 2 to 2814 days, interquartile range= 250 days).

Table 4.2. Demographic, social, clinical risk factors and circumstances of death among index and exposed cases

Variable	Total (N=117) N (%)	Index Cases (N=55) N (%)	Exposed Cases (N=62) N (%)	X ² P value
Demographic characteristics				
Sex	77 (65.81)	37 (67.27)	40 (64.52)	0.905
Aged 18 years or less	57 (48.72)	24 (43.64)	33 (53.23)	0.395
Aboriginal or Torres Strait Island origins	27 (23.08)	13 (23.64)	14 (22.58)	1
Employed	37 (31.62)	18 (32.73)	19 (30.65)	0.966
Student	38 (32.48)	17 (30.91)	21 (33.9)	0.885
Socioeconomic advantage and disadvantage (SEIFA) ¹	40 (34.19)	20 (36.36)	20 (32.26)	0.785
Residing in a remote location	15 (12.82)	7 (12.73)	8 (12.90)	1
Parent separation	39 (33.33)	12 (21.82)	27 (43.55)	0.022
Living alone at time of death	<10 (<8.50)	<5 (<9.10)	<5 (<8.10)	1
Social characteristics				
Relationship breakdown (past month)	23 (19.66)	11 (20.0)	12 (19.35)	1
Peer conflict (past year)	<10 (<8.50)	<5 (<9.10)	6 (9.68)	0.279
Family conflict	24 (20.51)	11 (20.0)	13 (20.97)	1
Binge drinking (past month)	23 (19.66)	14 (25.45)	9 (14.52)	0.210
History of abuse or neglect	<10 (<8.50)	<5 (<9.10)	12 (19.35)	0.020
Exposure to Domestic violence	<10 (<8.50)	<5 (<9.10)	5 (8.10)	0.060
Clinical characteristics				
Diagnosed or undiagnosed mental illness	62 (53.0)	35 (63.64)	27 (43.55)	0.541
Self-harm (past year)	<10 (<8.50)	<5 (<9.10)	<5 (<8.10)	0.871
Discharged from the ED ²	10 (8.55)	5 (9.10)	5 (8.10)	1
Illicit substances	35 (29.91)	20 (36.36)	15 (24.19)	0.218
Alcohol impairment	14 (12.0)	8 (14.55)	6 (9.68)	0.60
Circumstances of death				
Suicide note available	33 (28.21)	15 (27.27)	18 (29.03)	0.413
Told someone they wanted to die	49 (41.90)	19 (34.55)	30 (48.39)	0.184
Communicated on social media	<10 (<8.50)	<5 (<9.10)	5 (8.10)	0.265
Internet search for methods	<10 (<8.50)	<5 (<9.10)	<5 (<8.10)	1

¹ Socioeconomic Index for Advantage and Disadvantage bottom 20th percentile for relative disadvantage based on SA2 for place of residence

ED= Emergency department

Counts less than N=5 were aggregated to preserve anonymity.

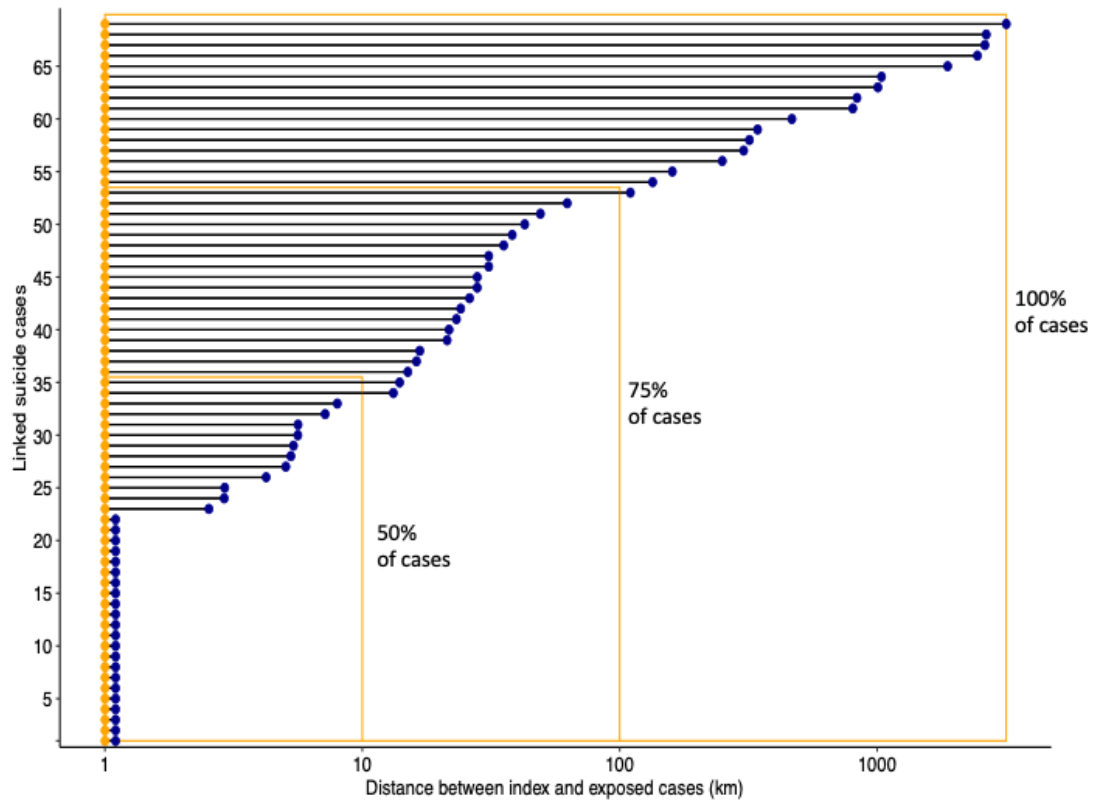


Figure 4.2 Geographic distance between index and exposed cases based on SA2 geography.

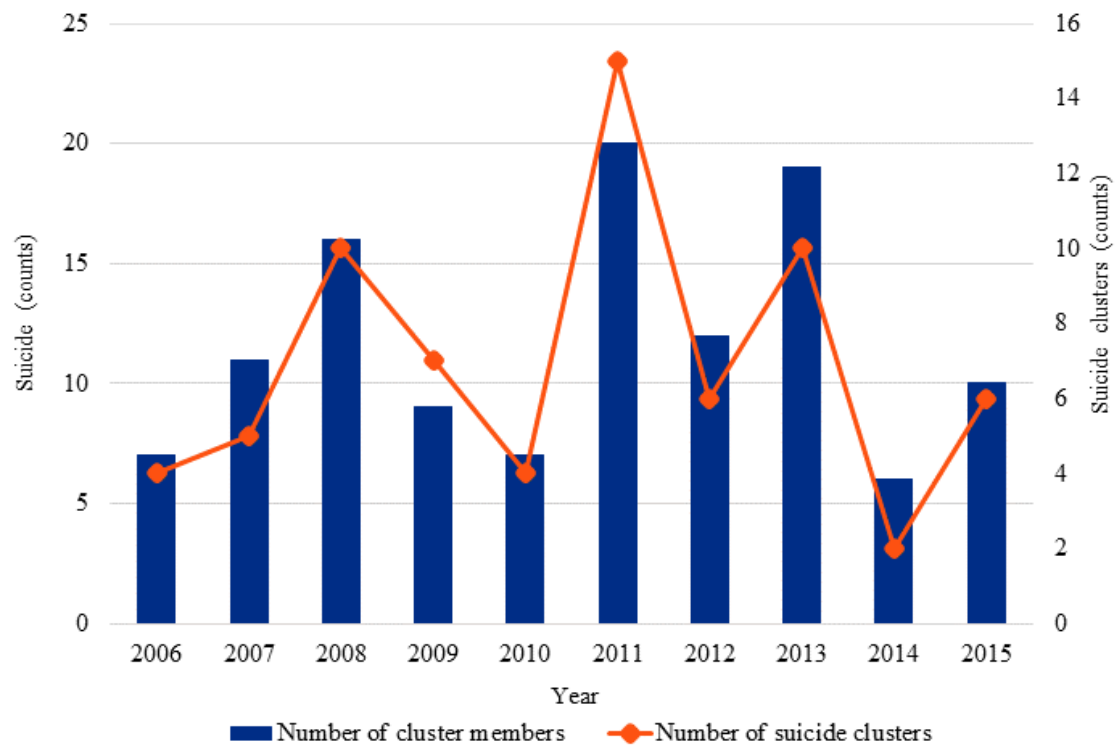


Figure 4.3 Number of incident suicide cluster events and cluster members by year (2006-2015)

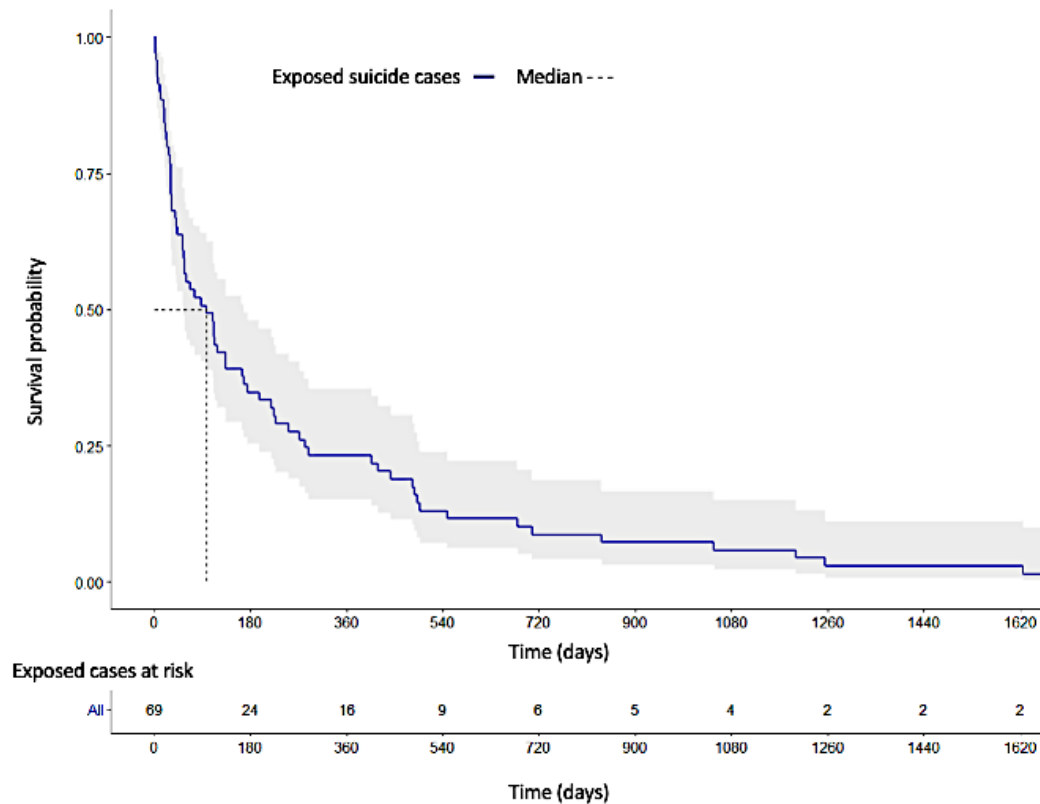


Figure 4.3 Survival time among exposed cases estimated by the Kaplan Meier method. The point on the x-axis where the horizontal dashed line at a survival probability of 0.50 intersects with the curve represents the estimated median survival time of exposed cases.

4.3.3 Investigation of assortative relating

Figure 4.5 presents the conditional probability that the exposed case had the same characteristic, given the exposure status of the index case. In 86% of cases (95% CI 0.7 to 1.0), the exposed case was also aged 18 years or less when the index case was in this age group. The probability that a young person was of Aboriginal and Torres Strait Island descent was 60% (95% CI= 0.3 to 0.9), when the index case was also of Aboriginal and Torres Strait Island descent. For young people living in remote or very remote locations, the probability in that an exposed case was also from a remote location was 67% (95% CI= 0.3 to 0.9). No further differences were observed between index and exposed cases for history of mental-ill health (83%, 95% CI= 0.71 to 0.94), illicit substance misuse (23%, 95% CI= 0.23 to 0.72), history of binge drinking (27%, 95% CI= 0.05 to 0.48) and the remaining demographic, social and clinical characteristics (**Table 4.3**).

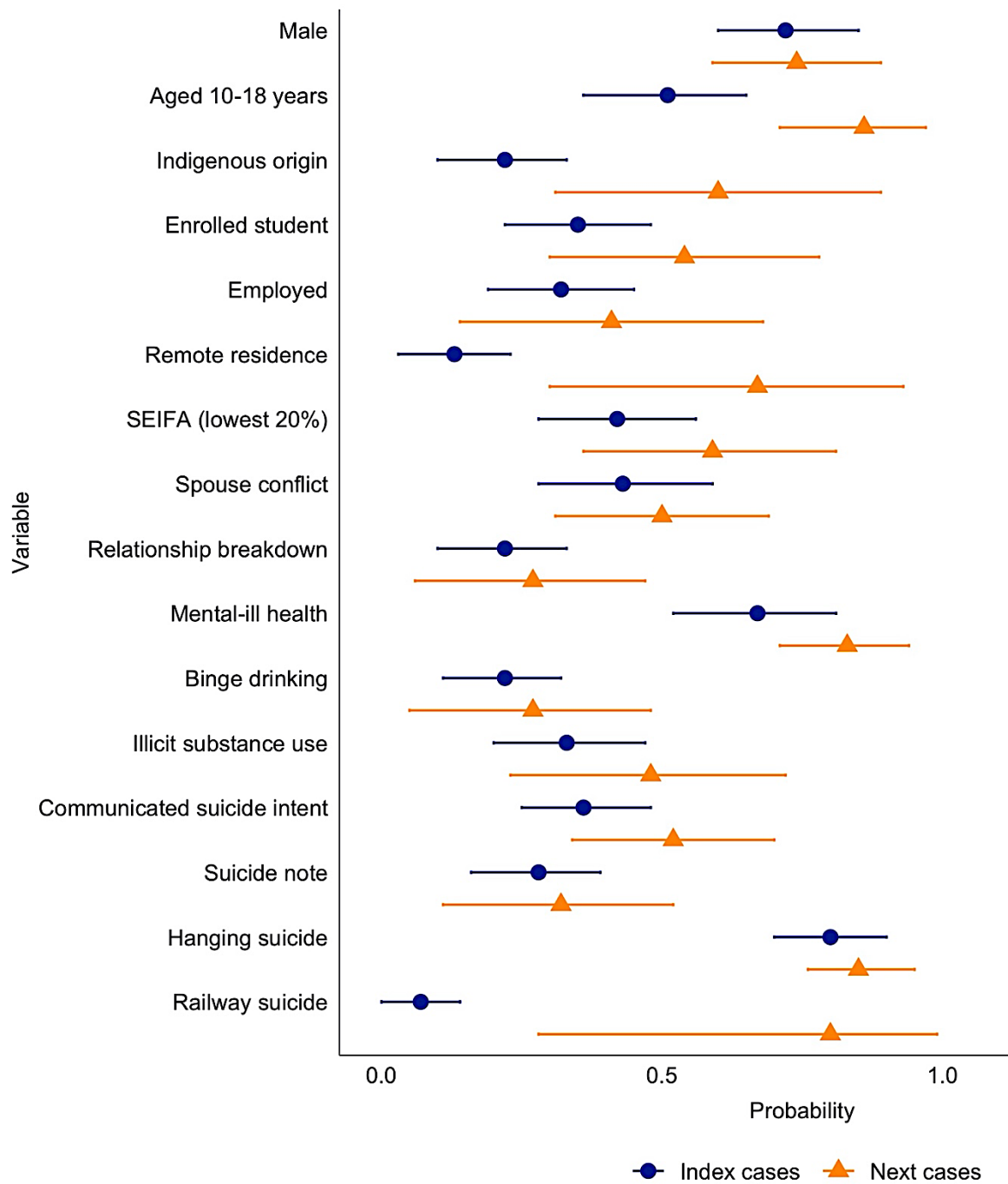


Figure 4.5 Casewise concordance among index and exposed cases who died in suicide clusters.

4.3.4 Investigation of the social transmission of suicide

Results of the casewise concordance analyses showed that exposed cases had an 80% (95% CI = 0.3 to 1.0) probability of dying by railway suicide when exposed to an index suicide that died by the same method (**Figure 4.5**). The conditional probability of additional methods (other than hanging) was not estimated due to insufficient numbers. No significant differences in probability were observed across the remaining characteristics (**Table 4.3**).

4.4 Discussion

This study investigated characteristics and circumstances of death of 117 young people aged 10-24 years who died in suicide clusters in Australia in 2006-2015. Results from the present study found evidence of both the social transmission of suicidal behaviour and assortative relating. In particular, by examining the concordance of demographic, social and clinical characteristics of index and exposed cases in a cluster, we found that the presence of pre-existing clinical characteristics such as mental-ill health, substance misuse, and history of binge drinking among index cases were not significantly associated with the probability that the same characteristics were present among exposed cases. Instead, young people who reside in remote communities and were of Aboriginal and Torres Strait Island background had a significant probability of being involved in a suicide cluster, when exposed to an index suicide of the same origins. Together these findings provide some evidence of assortative relating, but these findings were most robust in young people under the age of 18, those who were of Aboriginal and Torres Strait Island descent, and those resided in a remote location. Additionally, results from the present study provide indicative support for the role of the

social transmission of suicidal behaviour. In particular, young people who were exposed to the railway suicide of a peer had an 80% probability of dying by the same method. Given suicide by railway is a particularly rare and violent method, it is plausible that the social transmission of suicidal behaviour, facilitated by knowledge of the index suicide, accounted for this finding.

Results from the concordance analyses revealed that in nearly 80% of cases members of suicide clusters belonged to the same age group as the index suicide. These findings suggest that the younger cohort may be particularly susceptible to suicide following exposure to the suicide of a friend or acquaintance. Additionally, we found that 50% of exposed cases died within 90 days of exposure to an index suicide. Together, these findings suggest that the first three months of following exposure to the suicide of another young person may represent a period of heightened suicide risk and therefore represents a critical window of opportunity for the postvention and cluster response interventions with the aim of averting further suicide deaths.

Identifying the risk factors associated with suicide clusters has the potential to inform targeted cluster response strategies, with better precision. The finding that young people who reside in remote communities may be particularly vulnerable following exposure to the suicide of a peer suggests that remote communities should be particularly vigilant following a suicide in the community. For example, remote communities may benefit from developing a postvention protocol that ensures members of the community have adequate access to postvention support following a suicide. Furthermore, remote communities may benefit from universal suicide prevention interventions that equip gatekeepers to respond to those who may be at risk of suicide, particularly following a suicide in the community.

It is noteworthy that we found limited concordance between index and exposed cases based on clinical risk factors such as history of adverse mental health. Screening for suicide in high-risk populations is a core component of existing cluster response guidelines^{12-14,30}, despite evidence that that suggests that screening for suicide risk is associated with a positive predictive value of approximately 6%³¹. Instead, results of the present study suggest that the presence of pre-existing clinical risk factors may be less sensitive predictors of young people who are at risk of suicidal behaviour who are later involved in suicide clusters. Based on these findings, we recommend that, in addition identifying young people experiencing significant distress, screening efforts should be broadened to include identifying individuals who were friends of the deceased regardless of their pre-existing vulnerabilities, and when necessary, these young people should be provided with access to postvention support.

Further, since 50% of exposed cases died within the first 90 days of exposure, repeat screening during this period may be particularly warranted. It is equally important that communities are equipped with resources to effectively mitigate the social transmission of suicidal behaviour. To date, there is a paucity of studies that have investigated the effectiveness of interventions on preventing the social transmission of suicidal behaviour in young people³². The evaluation of community-based interventions in response to suicide clusters as well as the development of targeted interventions is essential to fill these critical gaps in evidence.

Although geographic proximity appears to be an important characteristic of the social transmission of suicidal behaviour, it is noteworthy that approximately 25% of index and exposed cases lived in regions that were separated by at least 100km in distance. The distance between index and exposed cases was poorly correlated with time,

suggesting that the distance between index and exposed cases did not increase over time (i.e., because of the relocation of exposed cases). One explanation is that the popular and widespread use of social networking and other digital media influences may facilitate the spread of suicidal behaviour among index and exposed cases². A study by Robertson and colleagues, investigated the social links between members of suicide cluster in a small rural community in New Zealand. By combining both an inferential and descriptive case study approach, the authors identified additional members who were linked to the suicide cluster via social media but did not meet the authors criteria for geographic proximity using statistical analyses alone³³.

Communication via the internet and social media is well ingrained in the lives of young people and although there are many benefits, there is a need to further equip young people to safely communicate about suicide online³⁴. This is particularly important given communication via the internet and social media has the potential to transcend traditional geographic boundaries associated with the development and maintenance of suicide clusters². Whilst existing frameworks for the detection, response and prevention of suicide clusters provide recommendations for safe reporting of suicide in the traditional media, communities may also benefit from the implementation of interventions that equip young people to communicate about suicide in online environments in a safe way (e.g., without interfering with the grieving process).

4.4.1 Limitations

Although the NCIS offers the best available information on suicide and external causes of death in Australia, the quality of data in the NCIS vary considerably between individual cases and coronial jurisdictions. Information on exposure to suicide and suicide characteristics was only available for analysis if it was queried during the formal

police or coroner investigation and reported by informants during the investigation. This resulted in the exclusion of 49 exposed cases that did not provide sufficient information on the index suicide. Furthermore, variables which were not reported in the police or coroner records were coded as not being present. Consequently, there was likely to be some misclassification bias, where absence of evidence was treated as evidence of absence. The limitations associated with the completeness and quality of the data, and the retrospective nature of the study, meant that the operationalisation of the social transmission of suicidal behaviour and assortative relating were limited to the variables reported in the NCIS and may therefore lack precision. For example, due to power limitations it was not possible to examine the concordance between other methods of suicide such as poisoning by gaseous substances that have been reported in previous reports of suicide clusters³⁵.

Our analysis of cluster-linked pairs was limited to young people aged 24 year or less who died by suicide during the study period. This resulted in the exclusion of 60 (29.7%) index cases over the age of 25. Given exposure to the suicide of an adult accounted for one third of exposure events, future studies ought to consider examining the characteristics associated with exposure to suicide across the lifespan. Additionally, due to the absence of existing methodologies to control for multiple dependencies in casewise analyses, it was not possible to determine concordance rates among index and exposed cases using multivariate analyses. Future studies which overcome these limitations in order to better understand the interaction between covariates in casewise analysis is therefore warranted.

Lastly, results of the casewise analysis revealed that young people who were exposed to the suicide of a peer who resided in a remote community or had Indigenous heritage

were likely to reside in the same community settings. Evidence of suicide clusters occurring in remote and indigenous communities is widely documented in both descriptive case studies and population-based studies using data from national suicide registries^{6,7}. However it is not clear whether these findings are consistent with the social transmission of suicidal behaviour or assortative relating hypothesis. It is possible that environments that are characterised by high levels of social cohesion enable the rapid spread of information between members of the community^{2,36}. For example, Important cultural practices and obligations around death, also known as sorry business, are experienced by direct and extended kinship networks and it is not uncommon for members of the clan to travel hundreds of kilometres to attend sorry business ceremonies^{37,38}. Future studies which investigate the mechanisms associated with suicide clusters in specific high-risk communities may provide important insight into these existing limitations.

4.4.2 Conclusions

Although young people involved in suicide clusters may be susceptible to a number of demographic, social and clinical risk factors, sharing these factors does not necessarily account for the association between index and exposed cases involved in suicide clusters. Instead, we found that the circumstances of death and social factors such as age of the deceased, remoteness of residence and Aboriginal and Torres Strait Islander heritage may be of equal importance for the prevention of youth suicide clusters. Findings from the present study have important implications for our understanding of who might be at risk of suicide following exposure to the suicide of a friend or acquaintance and provides important insight into potential strategies for preventing and responding to suicide clusters. In particular, we recommend that, in addition to

screening for suicide risk, individuals who were close to the deceased should be provided with access to postvention support and that interventions targeting young people at risk of being involved in a suicide cluster may be particularly beneficial within the first 90 days following a suicide in the community.

4.5 References

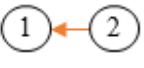
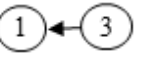
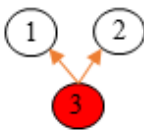
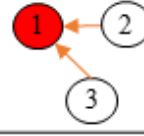
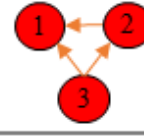
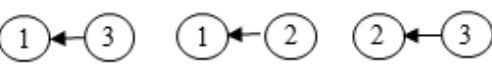
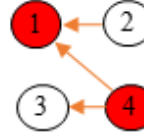
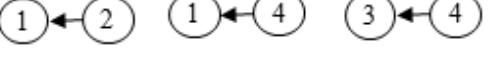
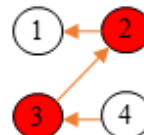
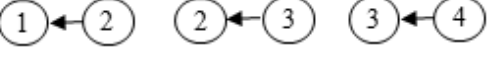
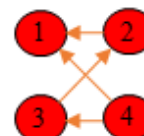
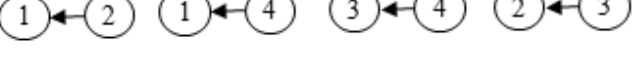
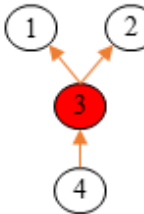
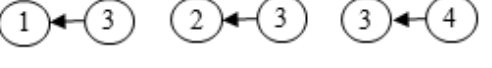
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4.5 Chapter 4: Supplementary martial

Table S4.2 Pair configurations and dependencies among young people involved in suicide clusters

Description	Cluster	Pair configuration
40 dyads; 1 pair per dyad Total pairs: 40		
2 Triads, 2 pairs per triad Total pairs: 4		
3 Triads, 2 pairs per triad Total pairs: 6		
2 Triads, 2 pairs per triad Total pairs: 6		
1 Tetrad, 3 pairs per tetrad Total pairs: 3		
1 Tetrad, 3 pairs per tetrad Total pairs: 3		
1 Tetrad, 4 pairs per tetrad Total pairs: 4		
1 Tetrad, 3 pairs per tetrad Total pairs: 3		

The numbers represent the sequence of death and the arrows represent the direction of exposure. Red circles represent dependencies within clusters (suicides that were both an index and exposed case AND/OR were included in more than one pair).

Table S4.3 Characteristics of linked and missing cases in the NCIS

Variable	Eligible for linkage		Missing Information		X ² P value
	N= 69		N=49		
	N	%	N	%	
Sex (male)	44	63.8	35	71.4	0.501
Aged 18 years or less	35	50.7	22	44.9	0.662
Aboriginal or Torres Strait Island origins	15	21.7	9	18.4	0.828
Employed status	22	31.9	16	32.7	1.000
Student status	23	33.3	19	38.8	0.679
Residing in a remote location	9	13.0	<5	<10.2	0.354 ¹
SEIFA ²	22	31.9	10	20.4	0.241

¹ Fishers exact test

² Socioeconomic Index for Advantage and Disadvantage bottom 20th percentile for relative disadvantage based on SA2 for place of residence

Table S4.4 Results of the casewise concordance among index and exposed cases who died in suicide clusters

	N exposed	N observations	Probability.	95% CI Lower	95% CI Upper
Male index case	50	69	0.72	0.60	0.85
Male exposed case	37	50	0.74	0.59	0.89
Illicit substances detected in index case	23	69	0.33	0.20	0.47
Illicit substances detected in exposed case	11	23	0.48	0.23	0.72
Indigenous index case	15	69	0.22	0.10	0.33
Indigenous exposed case	9	15	0.60	0.31	0.89
Aged 10-18 years index case	35	69	0.51	0.36	0.65
Aged 10-18 years exposed case	30	35	0.86	0.71	1.00
Employed index case	22	69	0.32	0.19	0.45
Employed exposed case	9	22	0.41	0.14	0.68
Enrolled student index case	24	69	0.35	0.22	0.48
Enrolled student exposed case	13	24	0.54	0.30	0.78
History of binge drinking index case	15	69	0.22	0.11	0.32
History of binge drinking exposed case	4	15	0.27	0.05	0.48
Mental ill health index case	46	69	0.67	0.52	0.81
Mental ill health exposed case	38	46	0.83	0.71	0.94
Told someone they wanted to die by suicide index case	25	69	0.36	0.25	0.48
Told someone they wanted to die by suicide exposed case	13	25	0.52	0.34	0.70
Residence in remote region index case	9	69	0.13	0.03	0.23
Residence in remote region exposed case	6	9	0.67	0.30	0.93
SEIFA (Bottom 20%) index case	29	69	0.42	0.28	0.56
SEIFA (Bottom 20%) exposed case	17	29	0.59	0.36	0.81
Suicide note index case	19	69	0.28	0.16	0.39
Suicide note exposed case	6	19	0.32	0.11	0.52
Family conflict (past year) index case	13	69	0.19	0.08	0.30
Family conflict (past year) exposed case	2	13	0.02	0.45	0.35
Relationship breakdown (past month) index case	15	69	0.22	0.10	0.33
Relationship breakdown (past month) index case	4	15	0.27	0.06	0.47
Conflict with spouse (past month) index case	30	69	0.43	0.28	0.59
Conflict with spouse (past month) index case	15	30	0.50	0.31	0.69
Methods					
Hanging index	55	69	0.80	0.70	0.90
Hanging exposed case	47	55	0.85	0.76	0.95
Railway index	5	69	0.07	0.00	0.14
Railway exposed case	4	5	0.80	0.28	0.99

SEIFA= Socio Economic Index for advantage and disadvantage (bottom 20th percentile) based on SA2 area of residence.

Chapter 5: General Discussion

The studies included in this thesis were specifically designed to address some of the core assumptions in the field of suicide cluster research. Specifically this thesis aimed to move the field forward in order to improve the way that communities respond to suicide clusters. Study one (**Chapter 2**) challenged the assumptions that point clusters based on both statistical inference, community expectation, and social links between cluster members are synonymous by posing the question ‘*Are commonly used definitions of suicide clusters comparable?*’. Study two (**Chapter 3**) was an effort to develop a more precise understanding of the association between exposure to suicide (a key proposed risk factor in the development of point clusters) and suicide attempt on subsequent suicidal thoughts and behaviours in others. Lastly, Study three (**Chapter 4**) advanced the field by posing the mechanistic question ‘*how does exposure to suicide facilitate suicide clusters?*’ albeit in an exploratory form.

The findings which follow from each of these empirical chapters pave the way for new avenues of enquiry, which extend the field beyond the mere identification of suicide clusters, towards a more precise understanding of their characteristics, risk factors and underlying mechanisms. As argued in this concluding chapter, meaningful progress requires the field to challenge previous assumptions backed by limited evidence and commit to a more precise definition and application of point clusters. This chapter presents a summary of the key findings described in this thesis. It is followed by a discussion of the strengths and limitations of the thesis and a critical analysis of the current state of the field in point cluster research. It sets forth recommendations to

strengthen research into point clusters and ensure its applicability in public health and practice.

5.1 Summary and key findings

5.1.1 Characteristics of point clusters

Chapter 2 examined three common definitions of point clusters that are included in both the peer-reviewed literature and existing public health guidelines for responding to suicide clusters, in order to examine whether different, commonly used definitions of point clusters yield comparable results. To the best of this candidate's knowledge, this is the first study to compare the similarities and differences between point clusters that are statistically significant, perceived to be significant and involve social links between cluster members using the same nationwide data. This study comprised all 3027 coroner determined suicides in young Australian's, over a 10-year period.

Chapter 2 sought to answer whether existing definitions of point clusters are characterised by the same spatial and temporal parameters, and whether they identify the same cluster members. In particular, this study sought to identify the extent to which the scan statistic overlapped with 1) point clusters that were identified by communities and investigated as part of a coronial inquests into point clusters and 2) point clusters that involved social links between cluster members. This distinction has not been adequately addressed in previous studies of suicide clusters, pointing once more to a lack of precision in the field of suicide cluster research.

The results presented in **Chapter 2** can be summarised into three key findings. First and foremost, this chapter showed that the same data, when analysed in different ways

identified markedly different point clusters. This was demonstrated by the significant differences in the location, size, duration of point clusters identified by the three common, yet methodologically different, cluster detection techniques. In doing so, the study showed that different methods for determining suicide clusters may have different implications regarding the scale of intervention that can be implemented. Whilst the inferential scan statistic is useful for identifying suicide clusters at a regional level, the technique may not be useful on a smaller scale for individual communities that are responsible for coordinating local suicide prevention activities. Lastly, contrary to conclusions drawn in previous population-based studies of point clusters using the scan statistic, the spatial and temporal parameters used to detect point clusters are not necessarily sensitive to point clusters that involve social links between cluster members¹⁻³. This was verified by a population-based study of social links between cluster members using descriptive network analysis.

5.1.2 Exposure to suicide

Chapter 3 sought to examine a fundamental assumption that underlies the three types of point clusters that were identified in **Chapter 2**, namely, the association between exposure to suicide and subsequent suicidal behaviour in others. To date, exposure to suicide has been identified both as a key risk factor and mechanism underlying the development of point clusters, yet it is not clear whether the association between exposure to suicide and subsequent suicide-related outcomes is equivalent when the exposure involves suicide attempt or composite measures of suicidal behaviour. Nor is it clear whether the association between exposure to suicide and suicide attempt is uniform when the outcomes involve suicide, suicide attempt or suicidal ideation. This is

a significant limitation of previous studies reported in both the suicide cluster literature and the field of suicide prevention, more generally.

This was the first study in the suicidology field to use multilevel meta-analysis to overcome dependencies between exposure and outcomes in existing epidemiological studies, allowing for a more precise understanding of the independent effects of different suicide-related exposures and outcomes. By means of comparison, one systematic review used meta-analysis to examine the independent association between exposure to suicide and exposure to suicide attempt on both suicide and suicide attempt outcomes⁴. However, the findings were limited to parents and offspring. Additional systematic reviews in the field that have examined the association between exposure to suicide and suicide attempt among friends and acquaintances combined measures of incidence with lifetime prevalence, which confounds the temporal association between exposure and outcome measures^{5, 6}.

In contrast, **Chapter 3** presents highly specific and up-to-date findings that provide a more detailed understanding of the association between exposure to suicide and suicide attempt on the independent outcomes, namely suicide, suicide attempt, and suicidal ideation. The findings reported in **Chapter 3** showed that exposure to suicide is associated with subsequent suicide and suicide attempt, but exposure to suicide attempt is associated with suicide attempt only. These results were comparable when the exposure occurred in a relative or friend and acquaintance. From a suicide cluster perspective, results from the systematic review and meta-analysis suggest that exposure to suicide and suicide attempt do not incur uniform risk across the range of suicide, suicide attempt and suicidal ideation outcomes. The findings provide key insights into

the potential risk factors associated with suicide clusters and pave the way for future studies involving the potential clustering of suicide attempt and/or self-harm behaviour.

5.1.3 Mechanisms and risk factors

Chapter 4 builds on the findings from both **Chapter 2** and **Chapter 3** to investigate the mechanisms underlying a specific type of point cluster, namely those which involve social links between cluster members. Specifically, the study sought to distinguish whether the association between exposure to suicide and subsequent suicide in young people involved in point clusters is associated with the social transmission of suicidal behaviour or is predominantly influenced by pre-existing risk factors among index and exposed cases, also known as assortative relating. Data used in this study comprised the same suicide cases used in **Chapter 2**, however, in this study each suicide and the corresponding police, coroner, autopsy and toxicology reports were individually examined for evidence of the clinical, social, and demographic risk factors as well as the circumstances of death.

Chapter 4 advances existing knowledge of the mechanisms underlying point clusters using a nationwide sample of suicides in Australian young people. To date, only one study has directly compared the mechanisms associated with mass clusters and point clusters using agent-based simulation modelling⁷. Whilst the authors found that the social transmission of suicidal behaviour (i.e., social learning) was more frequently associated with point clusters, relative to assortative relating models of suicide clusters, these findings were not validated using data from existing suicide events⁷. **Chapter 4** reported findings from casewise concordance analyses (a technique adopted from twin studies in epidemiology) to investigate that probability that young people who were

exposed to the suicide of a friend or peer shared the same demographic, social and clinical risk factors as index cases within a suicide cluster. The study used statistical techniques to overcome dependencies between index and exposed cases that were linked to more than one individual within a point cluster and used survival analysis to estimate the duration of risk among young people who were exposed to suicide and later died by suicide.

The findings in **Chapter 4** can be summarised into two key points. First, young people who were exposed to suicide and were involved in a suicide cluster did not cluster on the basis of pre-existing clinical risk factors. However social factors such as residential remoteness and Aboriginal and Torres Strait Islander background were common risk factors among index and exposed cases. Additionally, young people who were exposed to the suicide of another were more likely to share similar circumstances of death, such as the method of suicide used. Together these findings support both an assortative relating and social transmission model of point clusters. Second, results from the survival analysis shed light on the critical period of risk among young people who were exposed to the suicide of another and involved in a point cluster. These findings showed that the first three months (90 days) following exposure to the suicide of a friend or peer represents a period of heightened susceptibility to point clusters, which has important implications for preventative strategies.

5.2 Overall strengths and limitations of this thesis

5.2.1 Strengths

5.2.1.1 *Multiple dependencies*

Each of the three studies makes an original and substantial contribution to knowledge about the characteristics, risk factors and mechanisms of point clusters. The studies included in this thesis used advanced statistical procedures to overcome common limitations in suicide cluster research, and the field of suicide prevention more generally (i.e., multi-level meta-analysis to address dependencies in exposure and outcome measures in **Chapter 3**, and the adjustment of variance to account for multiple dependencies within clusters reported in **Chapter 4**). Multiple dependencies are common in epidemiological studies, where a single participant is asked questions related to multiple exposures and outcomes within the same study. It is particularly common in suicide research, which often combines suicidal thoughts and behaviours into composite exposure and outcome measures to account for low event rates and resulting power limitations. The findings reported in **Chapter 3** are novel, in that they used multilevel meta-analysis to adjust for dependencies within and between studies. In doing so the findings reported in **Chapter 3** provided a more detailed account of the independent effects of exposure to suicide and suicide attempt on suicide, suicide attempt and suicidal ideation outcomes, a finding which, thus far, has received little empirical attention.

5.2.1.2 *Study design*

In this thesis, considerable effort went into determining the chronology of events included in all three studies. Cross-sectional studies, by nature of their design are often

considered of lower quality among the full range of observational studies. This is because exposure and outcomes are measured at a single point in time as opposed to cohort and case control studies which take into account some degree of chronology between the exposure and outcome⁸. In **Chapter 3**, cross-sectional studies were included in the analysis if the temporal sequence between the exposure and outcome measure was pre-determined. Similarly, in **Chapters 2 and 4** the chronology between exposure to suicide and subsequent death by suicide was ascertained prior to analysis. This meant that procedures such as survival analysis could be used to estimate the duration of risk between index and exposed cases (**Chapter 4**), despite being cross-sectional in design. Cross-sectional studies remain a commonly used methodological design in suicide research, since other observational study designs such as cohort and case control studies can be costly and time consuming, given the frequency of suicide relative to other morbidities. Nonetheless, the methods used in this thesis demonstrate some of the techniques that can be used to optimise the quality of evidence reported in cross-sectional studies in the field of suicidology.

5.2.1.3 Minimising biases

The studies included in this thesis were carefully designed to minimise publication bias and to maximise reproducibility. For example, the multi-level meta-analysis reported in **Chapter 3** was pre-registered in PROSPERO and employed strict eligibility criteria, most notably the inclusion of studies which controlled for the temporal sequence between exposure to suicide, suicide attempt, and composite suicidal behaviour and subsequent suicide related outcomes. The full data set used in the analyses was included in the supplementary material in the published Article. It was not possible to publish the NCIS data used in **Chapters 2 and 4**, as per the NCIS data confidentiality and privacy

agreement. Nonetheless, a detailed description of the variables and coding procedures are provided in each of the studies included in the thesis for future studies which seek to replicate the findings reported in this thesis.

5.2.2 Limitations

5.2.2.1 Definitions of suicide clusters

The studies reported in **Chapters 2** and **4** were based on the same dataset and comprised all case records of confirmed suicides recorded in the NCIS in 2006 to 2015. However, there was some differences in how a suicide cluster was defined in each of these studies. **In Chapter 2** a suicide cluster was defined as three or more deaths that shared psychosocial links, in **Chapter 4** a suicide cluster was defined as two or more deaths that shared psychosocial links. The reclassification of the number of suicides that constitute a suicide cluster was largely influenced by new guidelines for responding the suicide clusters that were published during my candidature. In particular, the updated 2019 Public Health England¹⁹ guidelines note: *“A suicide cluster usually includes three or more deaths; however, two suicides occurring in a specific community or setting (for example a school) in a short time period should also be taken very seriously in terms of possible links and impacts (even if the deaths are apparently unconnected), particularly in the case of young people.”* Therefore, the decision to redefine suicide clusters on the basis of two or more linked cases was in keeping with the most recent best practice recommendations.

5.2.2.2 *Case ascertainment*

The studies reported in **Chapters 2 and 4** were based exclusively on youth suicides recorded in the NCIS. Although the NCIS is the best available resource on external causes of death in Australia, incidence measures of suicide based exclusively on coroner's verdicts of intent, may not reliably indicate all suicides that occur in the community⁹. For example, suicides may be undercounted when there is insufficient evidence of suicidal intent, leaving the cause of death uncertain. This may be particularly the case when the cause of death is due to single vehicle crashes, drowning, and overdose by pharmacological or other illicit substances when there is an absence of positive evidence such as a suicide note or verbal communication of suicidal intent¹⁰. Thus, although all cases included in the analyses were suicides, as determined by the coroner, it is possible some cases that were excluded from the analyses were misclassified as accidental or undetermined intent⁹. Previous studies of point clusters in the community have documented the emergence of point clusters following an unexpected or accidental death¹¹⁻¹³. Therefore, it is possible that several excluded cases may have contributed to the development of point clusters that were identified in this thesis. Future studies which examine the relationship between community trauma associated with other modes of death may provide important insight into additional risk factors associated with the emergence of point clusters.

To balance recency with case completeness, all suicides that were included in the analyses were limited to those which occurred in 2006 to 2015. This meant that inferences about suicide clusters in more recent years is limited. Delays in the accurate reporting of suicide data occurs internationally¹⁴ and is a common limitation of studies that involve data from suicide and self-harm registries¹⁵⁻¹⁷. Although policy decisions

are often based on retrospective data, communities that are tasked with responding to suicide clusters require access to suicide data in real time. Implementation of real-time surveillance systems for the detection of suicide clusters remains a key recommendation in existing cluster response guidelines¹⁸⁻²⁰ (see **Table 1.3** *'The core components of existing cluster response guidelines'* pp 40-41), however the suicide cluster literature, to date consists entirely of retrospective studies of suicide clusters. Despite this gap in evidence, several suicide and self-harm surveillance systems have been developed, including the National Self-harm Registry Ireland (NSHRI)²¹, the Bristol Self-harm Surveillance Register²² and the Thames Valley Real Time Suicide Surveillance System (TV-RT-SSS)²³. Future studies which seek to replicate the findings reported in this thesis using more recent data that is collected by existing surveillance systems have the potential to better inform the ways that communities respond to suicide clusters (further information on responding to suicide clusters is presented in more detail in section 5.3 *'Implications for responding to suicide clusters'*).

5.2.2.3 Data quality

Of the suicides that are positively identified by the coroner, the quality of information included in the NCIS is influenced by the quality and reliability of data obtained from informant interviews with relatives, friends and acquaintances. Factors such as recall bias, stigma²⁴, and absence of knowledge may impact the reliability of information reported as part of the police investigation. Consequently, all risk factors reported in the present thesis based on the free-text analysis of police and coroner reports should be interpreted with caution and the absence of evidence should not be interpreted as evidence of absence.

The absence of reliable data in the free text of police and coroner reports is particularly evident in **Chapters 2 and 4**, whereby approximately 40% of suicides in young people who were exposed to the suicide of another young person could not be linked using the information recorded in the NCIS. Whilst linked and unlinked cases did not significantly differ across the range of core demographic characteristics recorded in the NCIS, findings reported in this thesis nonetheless underestimate the burden of point clusters which comprise social links between cluster members. This limitation has important implications for the detection of point clusters in the community. It is recommended that exposure to suicide be collected as part of routine police and coroner investigations into suicide in future.

5.2.2.4 Populations at risk

Previous population-based studies, using the scan statistic, have shown that young people who die by suicide are more likely to be involved in point clusters relative to adults aged 24 years and above^{2, 25}. The studies included in **Chapter 2 and 4** were limited to young people aged 10-24 years to improve the quality of the evidence for this high-risk age cohort. However, this decision led to the exclusion of approximately one third of young people who were exposed to the suicide of an adult aged 24 years and above. A consequence is that point clusters comprising a combination of both young people and adults were excluded from the analyses and may have resulted in an underestimation of point clusters in the included studies.

That suicide clusters may comprise a combination of both young people and adults has important implications for future studies and the detection and response to suicide clusters in the community and cautions against the use of arbitrary age-limits when detecting point clusters, particularly those which involve social links between cluster

members. This recommendation is further supported by the results of the meta-analysis included in **Chapter 3** which found that exposure to suicide and suicide attempt was associated with comparable risk of subsequent suicidal behaviour among young people and adults. However, as noted in **Chapter 3**, the dichotomisation of age groups may have impacted the precision of these results. Future studies that seek to understand the characteristics, risk factors and mechanisms underlying point clusters across the lifespan are nonetheless warranted.

5.3 Implications for policy and practice

Notwithstanding the limitations cited above, this thesis has contributed to the development of a clearer understanding of the characteristics, risk factors and mechanisms underlying point clusters, which in turn will assist communities to be better equipped to respond to point clusters. As noted above, existing public health guidelines for responding to point clusters define point clusters in multiple ways, yet it is unclear whether different point clusters require different cluster response interventions in order to avert further suicides during an emerging point cluster. This section discusses in detail the implications of the findings presented in this thesis with regards to policy and practice, with a particular focus on the real time surveillance of suicide clusters and policy recommendations for responding to suicide clusters.

5.3.1 Towards a more precise definition of point clusters

Systematic collection and curation of data on suicide and deliberate self-harm is critical to the planning of mental health services and for underpinning strategies for detection, prevention, and response to suicide clusters. Real-time suicide surveillance systems have been established in New Zealand which operates under the Ministry of Health

Coronial Suspected Suicide Data Sharing Service (CDS)²⁰, the Suicide and Self-harm Observatory (SSHO)²¹ in Ireland, the National Violent Death Reporting System (NVDRS) in the US²² and the Thames Valley Real Time surveillance system in England²³. These systems provide an opportunity to identify potentially emerging clusters of suicide and if established correctly, can trigger an immediate community response, thereby reducing the risk of further suicides or suicide attempts as well as related morbidity among those bereaved or exposed to suicide. In 2018 the Australian government announced a taskforce responsible for development of an Australia-wide rapid surveillance system for the detection of suicide clusters²⁶. This section explores some of the implications which follow from the empirical studies in this thesis in the context of real-time surveillance of suicide clusters and puts forth recommendations for optimising the detection of suicide clusters in the community.

To date our understanding of point clusters has been informed by inconsistent definitions of point clusters that have been operationalised using substantially different methodologies. Lack of consistency in the field has resulted in contradicting definitions within existing public health guidelines, which describe point clusters on the basis of multiple suicide deaths that may or may not be validated using inferential techniques and may or may not involve social links between cluster members. As shown in **Chapter 2**, existing definitions resulted in the identification of point clusters that were markedly different in terms of the geographic location, duration, and the characteristics of individual point clusters and cluster members. Ideally, the preferred definition of a point cluster is one that can be supported by inferential techniques, such as the scan statistic. However, the reliability of inferential methods requires that the spatial,

temporal and social parameters are relevant to stakeholders that are responsible for coordinating suicide prevention activities.

Existing suicide surveillance systems operating internationally typically provide statistical verification to a community in response to stakeholder concern regarding an emerging suicide cluster. In the US the Center for Disease Control provides statistical verification to communities that report a suspected suicide cluster and deploy public health officials to assist the community with an investigation into the deaths. In contrast, in New Zealand, the Coronial Suspected Suicide Data Sharing (CDS) service notifies local community district health boards (DHBs) of instances of suspected suicides in their regions and provides verification to communities that make contact with the CDS regarding an emerging suspected suicide cluster²⁰. The bidirectional model in New Zealand means that communities are approached with statistical verification of a suicide cluster. By the same token, community stakeholders have the means to request support to verify a suspected or emerging suicide cluster. The findings in **Chapter 2** suggest that a bidirectional model for the detection of suicide clusters may be particularly helpful to communities, given there was limited evidence between statistically significant suicide clusters, suicide clusters that involved social links between cluster members, and coronial inquests into suicide clusters. This approach would require that resources be directed specifically to routine data-monitoring operations including geospatial analysis of suicide events, as well as the collection of information on the social links between cluster members. The contribution of the current thesis to each of these operations are outlined in further detail below.

5.3.1.1 Spatial parameters

In order to provide communities with routine surveillance of potential or emerging suicide clusters, it is imperative that the spatial parameters align with the relevant public health jurisdictions that are responsible for the surveillance of suicide clusters and coordinating a response to a suicide cluster. The findings presented in **Chapter 2** showed that the use of broad area aggregation into SA2 spatial units were not sensitive to coronial inquests into point clusters, nor point clusters that involved social links between cluster members. Together these findings suggest that point clusters that are detected at an SA2 level may not be relevant to local suicide prevention committees (including, councils, police, schools, or other community organisations) that are tasked with responding to clusters.

That suicide clusters detected using the scan statistic (a common method for determining suicide clusters) did not significantly overlap with suicide clusters that were perceived to be significant (operationalised by coronial inquests into suicide clusters) nor those which involved social links between cluster members highlights a significant gap which hinders the translation of evidence into practice. For example, existing studies of point clusters in Australia using the scan statistic have typically involved broad area aggregation comprising postcodes, local government areas or SA2^{17, 27-29}. In particular, the findings reported in **Chapter 2** suggest that broad area aggregation of spatial units at the SA2 level do not necessarily correspond with the spatial boundaries that are meaningful to communities that are responsible for responding to suicide clusters. In Australia, Primary Health Networks are appointed in each state and territory to establish and deliver access to healthcare services, including

suicide prevention and postvention support and would be a suitable region with which to identify suicide clusters.

The identification of suicide clusters using reliable, replicable, and empirical methods is an important priority in the field of suicide prevention and there is a need to develop methods for determining suicide clusters that are relevant to different scales of intervention (e.g., at the national, regional and community level). The use of point-level data has been shown to effectively distinguish between spatial clusters of suicide in small regional communities but is difficult to obtain³⁰. Furthermore, dependence on coronial verdicts of suicide in nationwide datasets presents a challenge for real time surveillance, which due to the coronial process, can be delayed for up to two-years^{9, 31}. These factors are important considerations for communities that may require a timelier response to suicides when they occur and can be used to guide the implementation of real time surveillance systems in communities where none exist.

In terms of future studies in the field of suicide cluster research, an important next step involves investigating whether data acquired at the point-level improves the sensitivity and specificity of the scan statistic in the detection of point clusters that are characterised by social links between cluster members and are meaningful to communities that are tasked with responding to point clusters. Additionally, the use of multiple data-sources (e.g., first responders such as police, emergency departments, and other community services) to improve the timely response to suicide clusters that are detected with inferential methods are particularly warranted, since these data sources are often used by communities, on the ground, who are tasked with responding to suicide clusters^{11, 32-39}.

5.3.1.2 Temporal parameters

The finding that point clusters may operate over a three-year period also has important implications for real-time surveillance of suicide clusters and the long-term evaluation of cluster response strategies that are implemented in the community. Previous studies that have used the scan statistic to detect point clusters have used a range of pre-determined spatial parameters that have been largely informed by small descriptive studies of point clusters in specific settings such as schools and remote indigenous communities^{1-3, 17, 27}. A consequence is that the long-term evaluation of cluster response activities is either not completed, or under-reported, leading to a significant gap in policy and practice.

A key barrier identified by stakeholders who have experienced a suicide cluster is the lack of evidence to guide long-term planning, particularly when there is no clear evidence on how long a suicide cluster may occur^{32, 35}. The findings reported in this thesis offers communities new insights with which to address this problem. For example, **Chapter 2** showed that suicide clusters may operate for up to a maximum 3-year period. This finding has important implications for long-term postvention support within a community. Importantly, it provides communities with an opportunity to prepare for the long-term evaluation of postvention and cluster response and prevention initiatives that in turn have the potential to improve the quality and availability of evidence informing what works and doesn't work when responding to suicide clusters. This is important since evidence informing what works to avert further deaths in a community affected by a suicide cluster remains limited. A systematic review by Cox and colleagues⁴⁰, for example identified a total of five empirical studies documenting

cluster response interventions in the community, of which only one study recorded longitudinal outcomes over a five-year period¹¹.

5.3.1.3 Data sources

Chapters 2 and 3 show that exposure to suicide is a key variable for identifying point clusters that comprise social links between cluster members. Yet social parameters have not been considered in inferential studies of suicide clusters, such as those which used the scan statistic. The findings reported in this thesis challenge the long-held assumption that suicides that occur close in space and time are a valid proxy measure of social contiguity between cluster members. These findings raise important questions regarding the inclusion of core social parameters (e.g., exposure to suicide) in sentinel surveillance systems for the detection of point clusters. At a minimum this would require the collection of information on prior exposure to suicide as part of routine police and coroner investigations into a suicide. It was outside the scope of the present thesis to assess whether the routine collection of exposure to suicide increases the number of point clusters that are identified within a community. However, given that missing information led to the exclusion of approximately 40% of young people who had been exposed to the suicide of another (see **Chapter 2** and **Chapter 4**) future studies which investigate the inclusion of social parameters in the detection of point clusters in local communities may be particularly warranted.

The findings reported in **Chapter 4** also have important implications for the role of self-harm data in suicide cluster prevention. The finding that exposure to suicide was associated with a 3-fold increased risk of suicide attempt suggests that inclusion of suicide attempt data, for example hospital presentations for self-harm, may identify

additional cluster members. Currently, there is no consensus on what constitutes a suicide cluster and existing public health guidelines and policy do not consistently recognise self-harm data in the surveillance and detection of suicide clusters. Although it was beyond the scope of the present thesis to investigate the association between suicide clusters and self-harm rates within a community, the results presented thus far provide a plausible rationale for the inclusion of both suicide and self-harm data in the detection, response, and prevention of suicide clusters in the community.

5.3.2 Responding to point clusters

In addition to detecting suicide clusters, it is equally important that communities are equipped with reliable information on how best to respond to suicide clusters. Although there is clear government and community interest in the development of guidelines for responding to point clusters, as demonstrated by existing public health guidelines in Australia and internationally^{12,18-20}, it is imperative that guidelines align with the evidence and that standardised methodological approaches are used to optimise the way that communities respond to point clusters.

The findings reported in this thesis have clear policy implications in terms of improving future cluster response guidelines and challenge one-size-fits all assumptions underlying existing conceptualisations of suicide clusters. Instead, this thesis demonstrates that different point clusters may be associated with different characteristics, risk factors and mechanisms. For example, **Chapter 3** showed that exposure to suicide and suicide attempt do not incur uniform risk across suicide, self-harm, and suicidal ideation outcomes and **Chapter 4** showed that point clusters of a particular type (namely those which involve social links between cluster members) can be distinguished on the basis

of the social transmission of suicidal behaviour or pre-existing social and clinical risk factors.

This section discusses the findings of this thesis with regards to responding to suicide clusters. It examines some of the key recommendations in existing cluster response guidelines that are relevant to the findings that are reported in this thesis and puts forth recommendations for future research for responding to, and preventing, point clusters.

5.3.2.1 Critical windows of opportunity

This thesis demonstrated the first three months following exposure to suicide represents a period of heightened suicide risk (**Chapter 4**). The duration of risk associated with cluster membership has not been reported in previous descriptive and population-based studies of point clusters. Although different suicide clusters may be associated with different risk factors, the finding that 50% of young people who were exposed to the suicide of another and subsequently died by suicide within the first 90 days of exposure has important implications for the prevention of suicide clusters that involve social links between cluster members. In particular, interventions that target the social transmission of suicidal behaviour (e.g., those which reduce prolonged negative exposure) may be particularly relevant during this critical time period (interventions targeting the social transmission of suicidal behaviour are discussed in more detail in section 5.3.2.2

‘Preventing the social transmission of suicidal behaviour’).

That the first 90 days following exposure to the suicide of another represents a critical window of opportunity for preventing subsequent suicide in others has important implications for policy and practice. To date public health guidelines for the detection, response, and prevention of suicide clusters have not specified the minimum duration of

risk. Similarly, postvention guidelines that seek to prevent further suicides and promote recovery in school settings do not provide specific information with which to guide the duration of assertive interventions during the period in which suicide risk is greatest. The results presented in this thesis, are the first to provide such evidence. It is recommended that future revisions of existing cluster response and postvention guidelines targeting youth be updated to include the most recent evidence.

Additionally, the finding that point clusters may last for up to three-years in duration (**Chapter 3**) and highlights the need for immediate interventions and the salience of establishing prevention approaches that are sustainable – rather than just brief, to deal with the potential prolonged trauma effects of a suicide death within a community. As noted previously, evidence identifying the effectiveness of long-term strategies in the prevention of further suicides in response to suicide clusters is limited as long-term evaluations of cluster response strategies are either not conducted, or not reported. To date, four studies have reported strategies for long-term maintenance of suicide prevention activities in the community^{11, 35, 41, 42}. These strategies included gatekeeper training to parents, stakeholders, and teachers^{11, 41, 42}, as well as education in emotional resilience^{11, 35, 42}. Nevertheless, it is unclear whether the gains in knowledge resulting from gatekeeper training translate into behaviour change which is sustained over a long-term period. Evidence supporting the long-term outcomes of gatekeeper training on mental health literacy, help-seeking behaviour, and recognising the warning signs of suicide have been reported in two studies at both 3-months⁴³ and 12-months follow-up⁴⁴. Both studies revealed small-to-moderate effect sizes, which were most robust among those with lower baseline scores for mental health literacy⁴⁵.

The implications in policy and practice which follow are two-fold. First, future studies should seek to optimize the delivery of gatekeeper training programs to improve the duration in which knowledge gains are sustained within the community. Second, existing frameworks for responding to suicide clusters ought to be updated to include more precise guidelines for the minimum and maximum duration of suicide clusters. This information would equip stakeholders and decision makers with critical information for not only implementing the right interventions, but also securing the necessary funds to sustain postvention activities during over both the short and long-term period.

5.3.2.2 Screening for individuals at risk of being involved in a suicide cluster.

Although it was beyond the scope of this thesis to determine which interventions may be most effective for different point clusters. The findings in this thesis provide some important insight into existing cluster response interventions. For example, screening for family, friends, peers, and acquaintances of the deceased for suicide risk remains a core component of existing cluster response guidelines^{12, 18-20, 46-48} despite evidence showing that existing screening instruments have limited predictive validity⁴⁹. Based on the findings reported in the casewise analysis (**Chapter 4**) screening efforts may be best directed towards identifying individuals who have been exposed to the suicide and have detailed knowledge of the circumstances of death and ensuring that screening efforts are followed up with adequate referral, social support or treatment (e.g., providing relevant caretakers with information on means restriction— at least when there is some evidence that an emerging point cluster may be facilitated by the social transmission of suicidal behaviour).

5.3.2.3 Preventing the social transmission of suicidal behaviour

The findings presented in this thesis provide further support for the social transmission of suicidal behaviour in young people exposed to the suicide of another. Yet existing public health guidelines for responding to suicide clusters provide little information on how to mitigate the social transmission of suicidal behaviour, with the exception of responsible reporting of suicide in the media. Coordinating the safe reporting of suicide in the media (e.g., sensationalised or graphic portrayals of the suicide death) is the most frequent strategy reported in studies that document a community's response to suicide clusters^{11, 33, 34, 36-38, 50}. Yet previous studies have shown that many young people learn about suicides in the community via social media and the internet^{35, 51, 52}. Guidelines for safe communication about suicide on social media (known as #chatsafe)⁵³ have been developed for young people and these include information on how to share the news of a suicide death. There is also a corresponding resource for communities involved in responding to a suicide cluster⁵⁴ and an evaluation is currently underway to assess the effectiveness of these guidelines among young people who have been bereaved by suicide in the community.

Although the #chatsafe guidelines address a critical gap in the evidence, particularly with regards to digital technology, there remains a significant gap in evidence informing community setting (e.g., schools) in the management of the social transmission of suicidal behaviours following exposure to suicide. For example, there is limited empirical evidence that has assessed the potential harms and protective factors associated with memorialising the deceased in a safe way and without interfering with the grieving process. There is some evidence that one-on-one counselling is more efficacious than group counselling. For example, in one case study, group counselling

was associated with sensationalised conversations and an increase in subsequent suicidal behaviours⁵⁵, which reduced when individuals received one-on-one counselling. Another case study found that turning a student's locker into a memorial shrine was viewed positively by students in the wake of a suicide⁵⁶. These gaps in evidence remain important avenues for future research, and will significantly benefit stakeholders (e.g., schools) who are responsible for responding to suicide clusters but are guided by limited empirical evidence. It is a genuine hope that the findings reported in this thesis start a new conversation about how best to move forward and address these critical gaps in evidence.

5.4 Conclusion

The detection and response to point clusters is a public health priority. Yet despite over 60 years of research, little progress has been made with regards to the prevention of point clusters. This thesis sought to move the field forward, by examining some of the core assumptions in the field and promoting new avenues for future research.

This thesis makes a strong case for distinguishing between different types of point clusters, so that communities can be better equipped to respond and avert further suicides and self-harm events. It revealed important methodological factors that may influence our understanding of the characteristics and mechanisms of point clusters and provided insights into the use of diverse inferential techniques to overcome some of the methodological challenges that exist in cluster research and the field of suicide prevention research, more generally.

Beyond this, this thesis was the first to examine social linked clusters on a nationwide scale; it was the first to quantify the independent effects of exposure to suicide and

suicide attempt on the independent outcomes of suicide, suicide attempt and suicidal ideation; and was the first to use nationwide suicide mortality data to identify the mechanisms underlying point clusters in young people who were exposed to the suicide of another.

Together the findings reported in this thesis make a case for the development of standardised methodological approaches in the detection of suicide clusters and shed light on new opportunities that have the potential to optimise the way that communities respond to point clusters— it is hoped that these findings will help inform future policy and practice in response to youth suicide clusters.

5.5 References

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Appendix: Publications

1. Hawton K, Hill NTM, Gould M, John A, Lascelles K, Robinson J. Clustering of suicides in children and adolescents. *The Lancet Child & Adolescent Health*. 2019;4(1):58-67.
2. Hill NTM, Too LS, Spittal MJ, Robinson J. Understanding the characteristics and mechanisms underlying suicide clusters in Australian youth: a comparison of cluster detection methods. *Epidemiology and Psychiatric Sciences*. 2020;29:e151.
3. Hill NTM, Robinson J, Pirkis J, Andriessen K, Krysinaka K, Payne A, et al. Association of suicidal behavior with exposure to suicide and suicide attempt: A systematic review and multilevel meta-analysis. *PLoS Med*. 2020;17(3):e1003074-e.
4. Hill NTM., Spittal M, Pirkis J, Torok M, Robinson J. Risk factors associated with suicide clusters in Australian youth: identifying who is at risk and the mechanisms associated with cluster membership. *EClinicalMedicine*. 2020; 29: e100631.