Australian suicide and hospitalised self-harm monitoring data.

A Scoping review of analytic methods used within the peer reviewed literature.

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Abstract

Suicide and intentional self-harm are significant problems for Australian communities. Monitoring suicide and self-harm hospitalisations is important for: the effective development of prevention and intervention initiatives; supporting accountability and transparency within systems and services that share responsibility for reducing suicide and self-harm; and robust program and system evaluations. This scoping review identifies and describes the peer reviewed academic literature that uses Australian suicide and hospitalised self-harm monitoring data. Our aim was to outline the analytic strategies authors use to draw meanings from this monitoring data, with a particular focus on change across time and spatial variance of suicide and hospitalised self-harm.

Four electronic databases were searched for studies published between 2000-2020 (ProQuest Central, Web of Science Core Collection, PubMed, and PsycInfo), and 132 articles were included.

Between 2020-2021, there was an overall increase in the number of peer reviewed publications addressing Australian suicide and/or hospitalised self-harm. Hospitalised self-harm is under investigated when compared to self-harm resulting in death. There is a significant delay between the generation of self-harm statistics and utilisation of that data by academic researchers. The very clear majority of article authors used ‘case only’ designs. Cohort and case-control designs, which are more able to provide information about causal inferences, were used infrequently. Few articles reviewed investigated spatial or spatiotemporal variance of hospitalised self-harm and suicide. Scan statistics were, by far, the most frequently used analysis authors of spatially or spatiotemporally focused articles. Of all articles reviewed, very few included analytic methods associated with data science and complex systems science.

Researchers using Australian self-harm monitoring data ought to reflect on the analytic strategies that have been used to date within the peer reviewed literature when formulating their future research agendas.

Keywords: Suicide, Self-Harm, Australia, Monitoring, Analytic Methods

Introduction

Suicide and hospitalised self-harm within Australia

Suicide and intentional self-harm are significant problems for Australian communities. In 2019, 3318 Australians were registered as dying by suicide (ABS, September 25 2020). In Australia, a total 115,221 years of life were lost to suicide during this period; accounting for more years of potential life lost than by any other cause of death (ABS, 2020). Further, in 2019, suicide was the 13th leading cause of all deaths, and over one third of deaths in people aged 15-24 years was due to suicide (ABS, 2020). It is estimated that non-fatal intentional self-harm resulted in 28,600 hospital admissions during the 2019-2020 financial year (AIHW, 2021a). In addition to the human cost, suicide and intentional self-harm places a very real monetary burden on the Australian economy. The Productivity Commission (2020, appendix H, pg. 165) estimated that the total economic cost of suicidal behaviour in Australia, is approximately $30.5 billion dollars per annum.

The importance of monitoring suicide and hospitalised self-harm

Population health monitoring involves regularly and systemically producing and disseminating data and knowledge about the health status of a population for the purposes of informing policymaking (Verschuuren & Oers, 2019). Effective suicide and self-harm monitoring systems have a range of potential benefits for Australian communities. Firstly, they provide information about rate of and risk factors for self-harming behaviours (Witt & Robinson, 2019). This, in turn provides important information upon which to design and target prevention and intervention initiatives (Department of Health, 2021; Productivity Commission, 2020). Monitoring may also support accountability and transparency within systems and services that share responsibility for reducing suicide and self-harm. Furthermore, monitoring data are often necessary for robust evaluations of relevant programs and systems (for example, Carroll et al., 2016). Stronger evaluations subsequently mean that funding and other resources can be more efficiently allocated based on community need and program efficacy. Finally, effective monitoring systems mean we can better measure the impact, on suicide and self-harm, of large events such as the recent 2019-2020 Black Summer bushfires (Davey & Sarre, 2020; Usher et al., 2021) and of the COVID-19 pandemic (John et al., 2020; John et al. 2020;2021).

The World Health Organisation (WHO) has recognised the importance of surveillance systems for suicidal and self-harming behaviour, releasing a practice manual for

stakeholders (WHO, 2016). Locally, The Australian National Mental Health Commission's (2018) Mental Health and Suicide Prevention Monitoring and Reporting Framework, and the Australian Productivity Commission's (2020) mental health inquiry both reiterate the need for robust surveillance systems. Both within Australian and internationally, academic research communities have also recognised the need to utilise population level suicide and self-harm data within research agendas ultimately aimed at reducing associated morbidity and mortality (for select relevant reviews see: Cho et al., 2016; John et al. 2020;2021, Knipe et al., 2019. For relevant publication using estimates of Global Burned of Disease Study 2016 see Naghavi, 2019). The current scoping review will identify and describe the peer reviewed literature that uses Australian suicide and hospitalised self-harm monitoring data. We will also outline the analytic strategies authors use to draw meanings from this monitoring data.

Learning from studies that use monitoring data

The focus of this review is not to synthesise study results. Instead, as stated, it is to describe the quantitative analytic methods peer reviewed studies have applied to Australian suicide and hospitalised self-harm monitoring data. Nonetheless, we believe, a brief overview of some key findings provides useful context for the review. It is clear that rates of suicide deaths are higher among males compared to females (Large & Nielssen, 2010; & Martínez-Rives et al., 2021). Although, while still lower relative to their male counterparts, suicide rates for Australian female youth may be rising (at least between 2004 and 2014) (Stefanac et al., 2019). Rates of hospitalised self-harm appear to be higher among females, as compared to males (Clapperton, 2019). Hanging as a method of self-harm appears to have increased in Australia, (between 1978 and 2017; Martínez-Rives et al., 2021). Furthermore, across Australia, those working in roles with access to lethal means (such as firearms, medicines or drugs, and carbon monoxide) may have higher rates of suicide compared to those employed in roles without access to lethal means (between 2001 and 2012; Milner et al., 2017).

There is a disparity in rates of suicide between areas of higher and lower socio-economic status within Australia and this disparity appears to have increased (at least up to 2013); with higher rates of suicides occurring in areas of lower socio-economic status (Too et.al., 2018). Additionally, the association between areas of higher unemployment levels and higher rates of suicide appears to be stronger in rural areas compared to urban areas (Rawlings et al., 2020). Looking more broadly, for a moment, to include data reflecting international experiences. Becoming unemployed is likely associated with higher levels of

psychological distress and this is felt most acutely in areas of higher unemployment; possibly due to the perception that prospections of re-employment are poor (Myles et al., 2017). Now returning to Australia, population level data show that individuals with low levels of education are more likely to die by suicide when compared to those who have obtained a tertiary education (particularly for younger males; Welsh et al. 2021).

Notwithstanding the resilience of Aboriginal and Torres Strait Islander peoples, Indigenous Australians appear to have elevated rates of suicide when compared to the non-indigenous Australian population (for a systematic review specific to Australian youth see Dickson et al., 2019; for a systematic review and comparison of Indigenous suicide rates globally see Pollock et al., 2018). Elevated rates of suicide among Aboriginal and Torres Strait Islander peoples are likely attributable (at least in significant part) to continuing impacts of colonialization (Smallwood et al., 2021). A now somewhat dated study using 2001-2008 data, investigated suicide risk for Australia's newest residents (Law et al.2014). Law et al. (2014) found that for males aged 25-39 years, first generation migrants were at greater risk of suicide compared to second generation migrants. Further, that males aged 25-39 years, third plus generation migrants (or 'locals') were at lower risk of suicide when compared to second generation migrants. Finally for adults aged 60+ (male and female), first generation migrants were at lower risk of dying by suicide when compared to second generation migrants (Law et al., 2014). A more recent scoping review undertaken by Patel et al. (2017), which primarily considered international register-based studies, found that migrants may be at greater risk of suicide and less likely to access mental health services.

Bowden et al.'s (2020) systematic review identified no studies investigating suicidality specifically among Australia's culturally and linguistically diverse (CALD) populations. Although CALD populations have been identified as a priority population for suicide prevention in Australia, it is not possible to discern CALD status within Australian National Government held suicide and self-harm monitoring data (AIHW, 2021b). Bowden et al. also argue that the dearth of academic research in the area is an important gap. It is important to note that, although migration status has been used historically as an imperfect proxy for CALD status, immigration and CALD status cannot be reliably interchanged (Pham et al. 2021). Lesbian, gay, bisexual, transgender or intersex (LGBTI) communities are also in the position of having been identified as priority populations but are not currently identifiable within national data assets (AIHW, 2021b).

The National Suicide and Self-Harm Monitoring Project

The Australian Government held a National Suicide Prevention Summit in December 2018 and subsequently committed to prioritising suicide prevention as a whole-of-government issue and a Council of Australian Governments (COAG) priority (NMHC, 2019). This commitment included both strengthening the delivery of suicide prevention interventions and establishing a national system for the timely collection and communication of self-harm and suicide data. Subsequently, the National Mental Health Commission (NMHC), the Australian Institute of Health and Welfare (AIHW), and the Department of Health have collaborated to progress the National Suicide and Self-Harm Monitoring Project (NMHC, 2019). The current scoping review is being undertaken, independently by the authors, towards supporting the AIHW in their work towards the National Suicide and Self-Harm Monitoring Project.

Need for the current scoping review

To the best of our knowledge, a systematic literature scoping has not yet been undertaken to describe the quantitative analytic methods used to interrogate Australian suicide and hospitalised self-harm monitoring data. The scoping review will identify and describes the peer reviewed academic literature using Australian suicide and hospitalised self-harm monitoring data. It will also outline the analytic strategies authors use to draw meanings from this monitoring data. This information has the potential to facilitate reflexivity across academic researchers and government stakeholder working within this space; creating opportunities to continue or change the way we approach monitoring data asset development and research.

A recent review of the Australian suicide prevention literature was undertaken by Schlichthorst et al. (2020). Schlichthorst et al. (2020) aimed to better understand the types of peer-reviewed studies published and grants/fellowships provided to progress knowledge with respect to suicide prevention in Australia. They undertook a review of studies published from 1999-2006 and 2010-2017; then examined any changed across the two time periods. Schlichthorst et al's coded reviewed studies according to: suicide behaviour (suicide, attempted suicide, suicidal thoughts, and other suicidal behaviour), suicide method/mechanism, target group (population of interest), and research setting (e.g. hospital, community, school). While there is some overlap between Schlichorst et al.'s (2020) study and the current study, there is also substantive divergence. Firstly, Schlichorst et al. focus on suicide behaviour (including suicidal ideation) only and not self-harm without suicidal

intent. Whereas the current review will scope studies investigating self-harm, regardless of suicidal intent, that results either in death or hospitalisation. Secondly, while Schlichorst et al. (2020) do provide a comprehensive overview of relevant Australian peer reviewed publications, they did not seek to describe the quantitative analytic strategies utilised by the authors of studies included within their review. The current scoping review will do so. Schlichthorst et al. (2020) and the current scoping review each provide distinct and meaningful contribution towards reducing the problem of suicide and self-harm in Australia.

Research questions

Our primary research question is: 1) What quantitative methods have been used to analyse Australian, monitoring level, suicide and hospitalised self-harm data? Our secondary research questions are: 2) What quantitative methods have been used to analyse change across time in Australian, monitoring level, suicide and hospitalised self-harm data?; and 3) What quantitative methods have been used to analyse spatial variance in Australian, monitoring level, suicide and hospitalised self-harm data?

Study characteristics in addition to the specific analytic methods will also be collected used (eg. publication date, population of interest, study rationale and aims) also provide important context for reflecting on results that more directly address our review aims.

Methods

Defining suicide and hospitalised self-harm

The complex nature of suicidal intent (intention to die) means that consensus has not been reached regarding the classification and nomenclature of different self-harming behaviours (with and without the intention to die) (carter et al., 2016). As such, for the purposes of this review, suicide is used to describe the death of a person subsequent to intentionally self-inflicted injury (by any mechanism). This is in line with the Australian Bureau of Statistics' production of suicide death statistics, which considers both deaths caused by intentional self-harm (ICD-10 codes X60–X84) and those that have sequelae of intentional self-harm (ICD-10 Y87.0; ABS, October 24 2020). Similarly, we define hospitalised self-harm as intentionally self-inflicted harm resulting in hospitalisation; regardless of whether the individual intended to die. The broader term 'self-harm' (not further specified) is used to describe both individuals hospitalised and dead subsequent to intentional self-harm.

The review does not address monitoring data relating to self-harm more broadly (i.e. not resulting in hospitalisation). While the monitoring of self-harm more broadly defined may have important public health implications, it is outside the scope of the current investigation. Equally, the current review does not address issues of measurement and data collection. This decision was made to constrain the scope of the review to make it more manageable, but also reflects the current policy priorities and AIHW operational need.

Search Strategy

To identify relevant peer reviewed journal articles the following electronic databases, were searched: ProQuest Central, Web of Science Core Collection, PubMed, and PsycInfo. Systematic searches were undertaken using terms to the effect of: (suicide OR (self-harm AND hospitalisation)) AND monitoring AND Australia. Full search strategy is included in Appendix A. To be included articles were: focused on the analysis of data capturing deaths and/or hospitalisations subsequent to intentional self-harm, peer reviewed, published between 2000 and 2020, and written in English. Review studies, studies including non-Australian resident data, qualitative only studies, articles not primarily focused on quantitative data analysis (for example: study protocols, or evidence-based commentaries), articles not primarily focused on suicide or hospitalised self-harm, and studies with no available full-text were excluded. Five articles returned by the search that did not strictly meet the criteria of hospitalised self-harm, were nonetheless included. Two of these studies

included data on self-harm ambulance attendances and one included data on emergency department presentations. The remaining two studies utilized health services (primary health care centre and enhanced police mental health service) data from remote communities that do not have reasonable access (due to distance) to hospital services.

All peer reviewed journal articles returned through the implementation of the search strategy were exported to Endnote citation management software and duplicates removed. Full citations for all articles that were included in the review are listed at Appendix B.

Data Collection

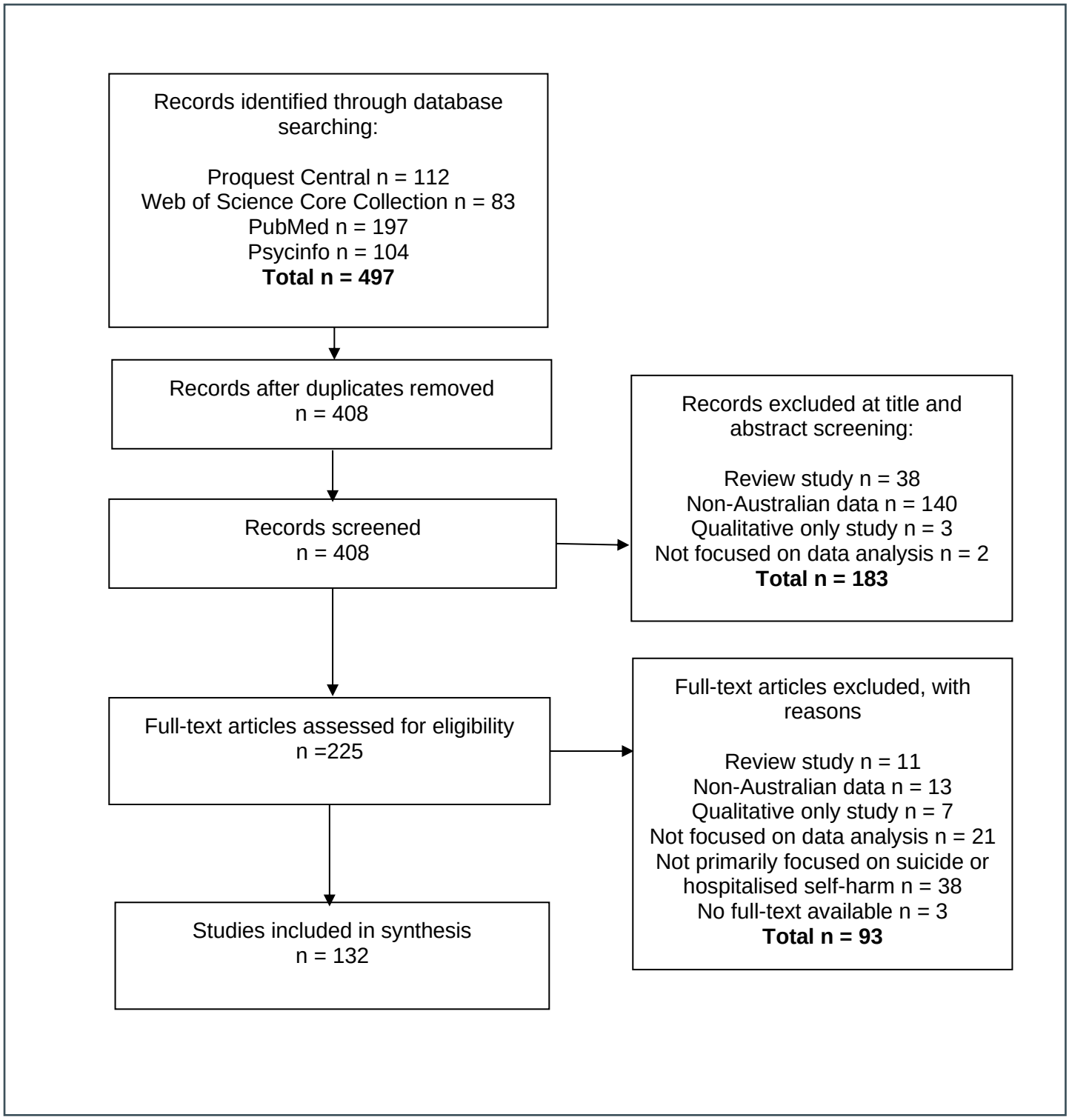
Covidence software was used to manage the publication screening and selection processes, and data extraction from selected publications. Title/abstract and then full-text screening was undertaken by a single author. Figure 1 outlines the data collection process. The full-text for each included article was then examined and data extracted by a single author. Data extraction was undertaken according to a standardised data extraction form co-designed by all authors. Data items extracted (and included in the current report) are: article focus on suicide and/or hospitalised self-harm; mechanism of self-harm; death or injury data other than intentional self-harm; spatiotemporal focus; stated primary study rationale; articulated study aims; rates used when reporting results; whether individual person level data used in analysis; whether individual personal level linked dataset used, years of self-harm data, level of geography and geographic coverage, population characteristics of interest, and quantitative data analyses used. Data describing the broader characteristics of reviewed studies was collected in order to provide context for those data points which more directly address our study aims.

When data extraction was complete, raw data were exported from Covidence to Excel for synthesis and analysis. A single author undertook thematic analysis (Braun & Clarke, 2006), grouping individual data points with the same or similar meaning into themes. Thematic analysis was undertaken within (and not across) data items. A second author was consulted where needed to ensure robust coding of data items to themes and to provide specialist knowledge of quantitative analytic methods included within the reviewed articles. Themes are largely inductive, with no themes firmly identified a priori. However, coding of themes was informed by the conventions of social science research methods. Inferential or meta-analysis was not undertaken because of broad methodological differences across studies and the descriptive nature of our research questions. Though-out the data synthesis and analysis, it became clear that more specific information was required for some data points to ensure the robustness of analysis and a specificity of findings. Consequently, data

extraction and analysis were somewhat iterative processes. Final data points for each article are included in the supplementary material.

Figure 1

Data Collection Flowchart



Results

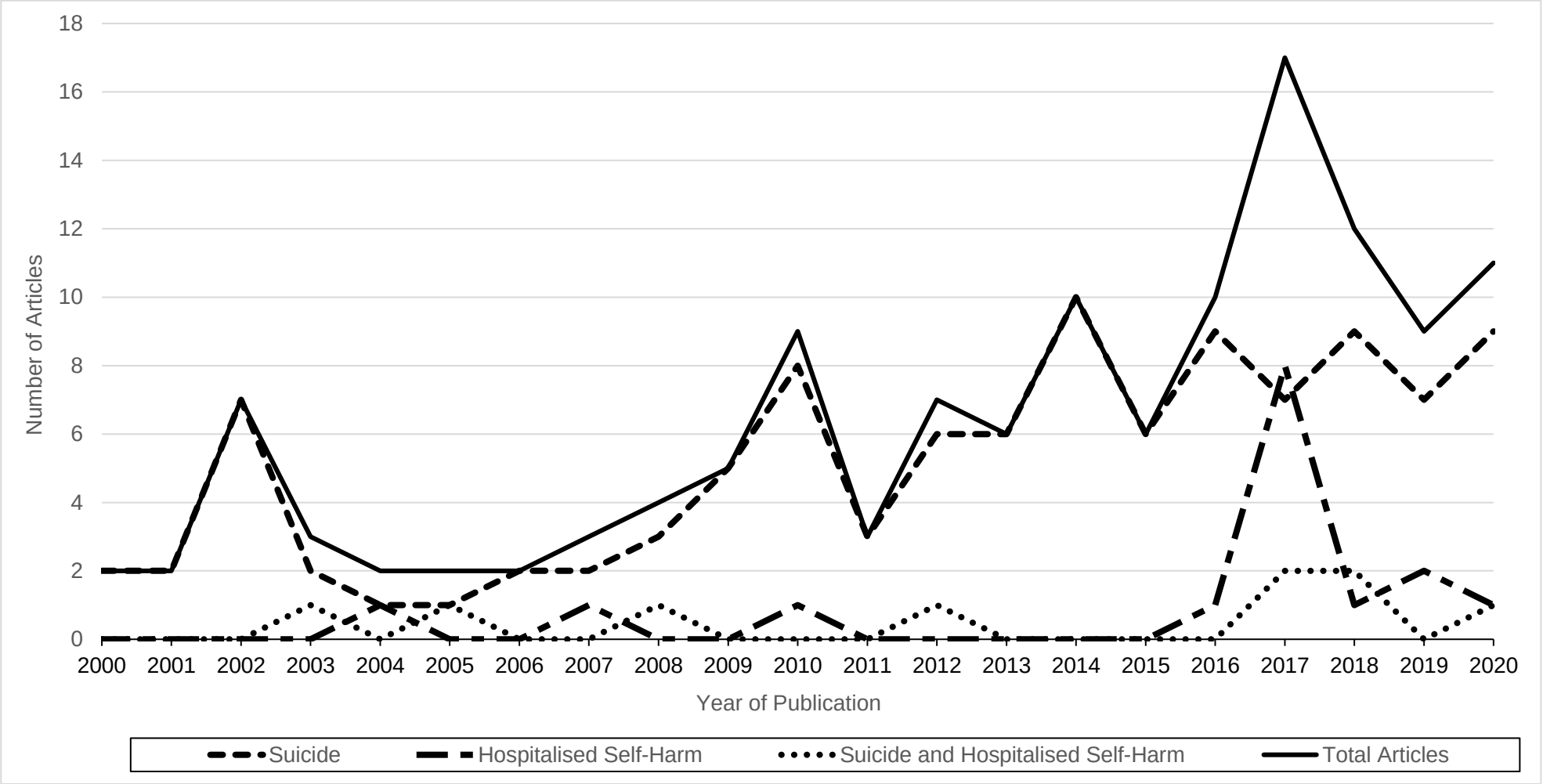
Self-harm focus: Suicide and/or hospitalised self-harm

Data was extracted from a total of 132 articles; 107 (81.1%) of these articles focused on analysis of population level suicide deaths data, 16 (12.1%) focused on hospitalised self-harm, and nine (6.8%) articles focused on both self-harm resulting in death and hospitalisation.

Figure 2 displays the year of publication and the suicide and/or hospitalised self-harm focus of each article. Descriptively it is clear that the total number articles published has increased between 2000 and 2020. Further, the number of articles addressing suicide only is significantly greater than the number of articles addressing only hospitalised self-harm or addressing both suicide and hospitalised self-harm. The exception to this is 2017, where there appears to be a spike in the publication of articles addressing hospitalised self-harm.

Figure 2.

Year of Publication and Self-Harm Focus of Articles



Fifty-nine (44.7%) articles did not include any data indicating the method or mechanism participants used to cause intentional self-harm. Forty-two (31.8%) included data about multiple self-harm mechanisms, but was not a specific study focus. For 19 (14.4%) articles, self-harm mechanism was a specific study focus and data was included about multiple methods. Twelve (9.1%) articles focused on a single self-harm mechanism: firearm deaths (3), hospitalised self-poisoning (3), railway deaths (2), hanging deaths (1), jumping from bridges (1), motor vehicles (1), and weighted drownings (1). Self-harm method was considered to be a focus of the study if it featured within the analysis and reporting as being of particular interest to authors (not included only within the sample description or as a covariate). Consequently, an article could be coded as focusing on self-harm method even if this was not explicated by authors within their study aims. For example, the study aim of investigating the misclassification of suicide deaths could be coded to the study aim of 'improving self-harm measurement.' Investigating the misclassification of deaths may well include a thorough examination of different mechanisms of death, and subsequently also coded as focusing on self-harm method. A total of 18 (13.6%) articles included data relating to death or injury not caused by intentional self-harm (in addition self-harm data).

Spatiotemporal focus

In total, 68 (51.5%) articles included a temporal component (but not a spatial component) in their analysis; addressing change in incidences of self-harm (resulting either in death and/or hospitalisation) across time. Nine (6.8%) articles addressed spatial variance (and not temporal variance) in self-harm incidences across different specific geographic locations (i.e. across local government areas, postal areas, statistical areas level 4, or statistical areas level 2). Five (3.8%) articles addressed both temporal and spatial variance. Fifty (37.9%) articles addressed neither temporal or spatial variance of self-harm. Twenty-seven (20.5%) articles, which did not seek to address spatial variance across specific locations, did nonetheless include a general level of remoteness indicator within their analysis (e.g. the Australian Department of Health's Rural, Remote and Metropolitan Area classification).

Narrower subgroups of articles' temporal, spatial, spatiotemporal focus, or other focus are documented within Table 1. Descriptively, the two largest subgroups were articles addressing cross-sectional differences between groups of people, and those investigating changes across time without an intervention (or exposure). Figure 3 displays spatiotemporal focus by year of publication. The number of articles published with different spatiotemporal focuses does not appear to follow a clear pattern across time.

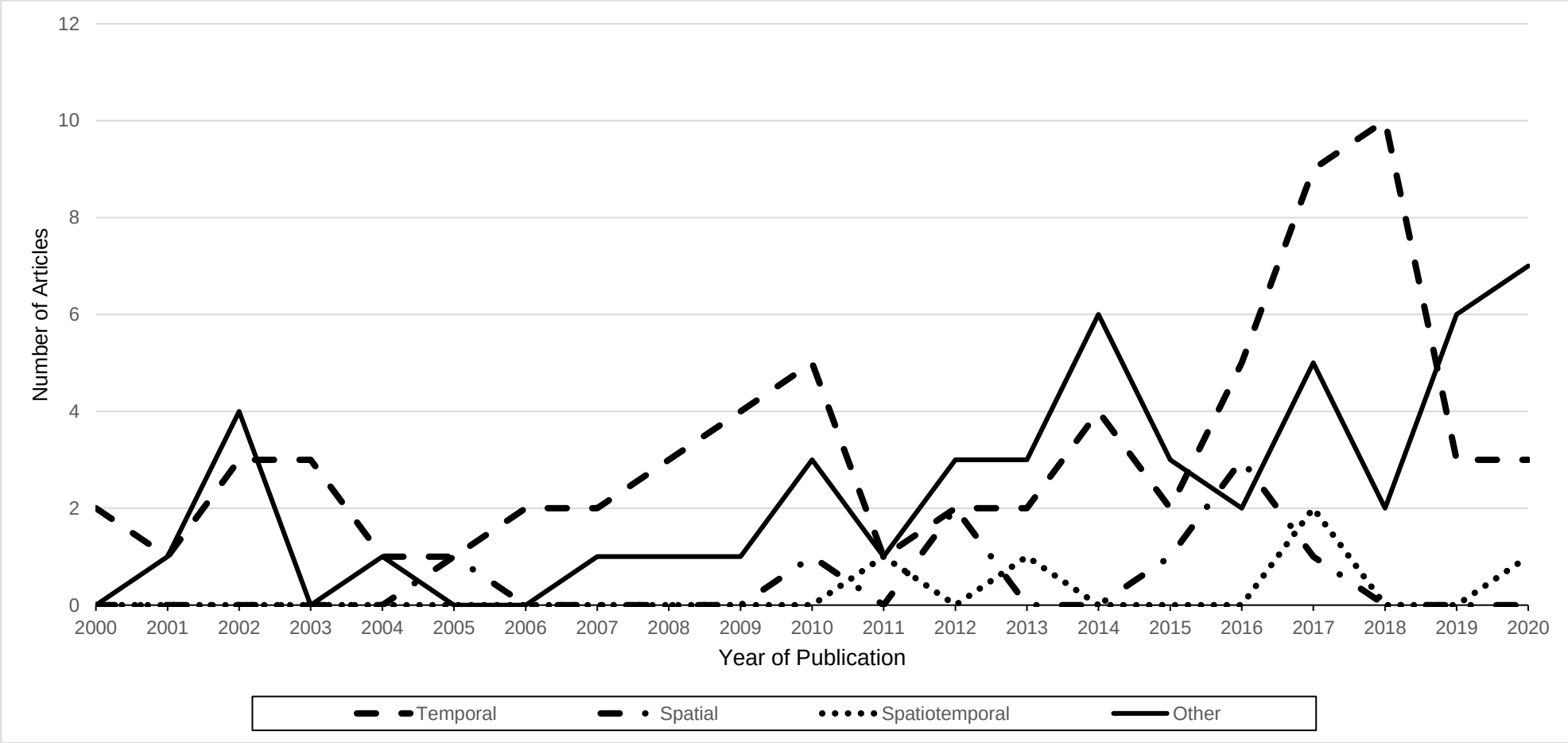
Table 1.

Temporal, Spatial, Spatiotemporal or Other Focus of all Articles

Temporal subgroups	n	Spatial subgroups	n	Spatiotemporal subgroups	n	'Other' subgroups	n
cohort follow-up	19	Spatial clustering	3	spatiotemporal clustering	1	characteristics and circumstances of self-harm incidences	12
more than two data time points with no exposure/intervention	32	spatial clustering and differences between cluster and non-cluster	2	spatiotemporal clustering and differences between clusters and non-clusters	3	differences between subgroups or a subgroup and the broader population	35
more than two data time points with exposure/intervention	15	associations with spatially constructed variables	2	differences based on spatiotemporally constructed variables	1	data quality investigation	3
two data time points - with exposure/intervention	2	differences based on spatially constructed variables	2				
Temporal Total	68	Spatial Total	9	Spatiotemporal Total	5	Other Total	50

Figure 3

Year of Publication and Temporal, Spatial, Spatiotemporal or Other Focus of all Articles



Study rationale and aims

The primary rationale for undertaking each study, as articulated by the articles author/s, was identified. Each article was coded to one rationale theme only. Where article author/s articulated more than one study rationale, articles were coded to rationale that was most salient (as determined by the coder). Study rationale themes identified were: to address a knowledge gap in the literature (43 articles, 32.6%); to assess or develop a service/intervention (26 articles, 19.7%); to address a group of people at heightened risk of self-harm (25, 18.9%); to improve data quality or improve measurement of self-harm (14, 10.6%); to extend the methodology of a previous publication (13, 9.8%); unclear or other rationale (5, 3.8%); justification based on academic theory (4, 3%) and; to identify factors associated with self-harm (2, 1.5%). Each article was coded to one or more study aims themes. The study aims were taken to be those articulated by the author/s of each article. These themes are outlined in Table 2 below.

Table 2.

Study Aim Themes

Study Aim Theme	Number of Articles n (%)
To examine individual, family, or community characteristics associated with self-harm.	33 (25.0)
To examine rates/counts of self-harm, as well as individual, family, or community characteristics associated with self-harm.	32 (24.2)
To improve the measurement of self-harm.	18 (13.6)
To examine rates/counts of self-harm in response to a community level exposure or intervention.	13 (9.8)
To examine the rates/counts of self-harm.	10 (7.6)
To undertake a mental health service evaluation or measurement of service utilization.	8 (6.1)
To examine rates and methods of self-harm	6 (4.5)
To investigate methods of self-harm, as well as examine individual, family, or community characteristics associated with self-harm.	4 (3.0)
To examine rates/counts of self-harm, methods of self-harm, and individual, family, or community characteristics associated with self-harm.	4 (3.0)
To improve the measurement of self-harm, as well as examining individual, family, or community characteristics associated with self-harm.	1 (0.7)
Study aims unclear.	3 (2.3)

Study design

Each article was coded to one of four study design groups: case only, cohort, case control, or mixed qualitative and quantitative. Case only design studies were defined as those where subjects were selected on the basis of a disease outcome only (i.e. suicide, hospitalised self-harm, or other cause of death or injury). For case-control design studies, researchers compared subjects with a suicide or hospitalised self-harm outcome (case) to those who do not but were otherwise similar (control). Cohort studies were defined as those where subjects were sampled on the basis of exposure (e.g. adverse childhood experiences, cancer diagnosis, release from incarceration) and the occurrence of suicide or hospitalised self-harm outcomes was assessed during a specified follow-up period (Christiansen et al., 2014; Glenn et al., 2016; Mathes et al., 2017). All articles including the analysis of both qualitative and quantitative data were coded to the mixed qualitative and quantitative design group. At 97 (73.5%) articles, the very clear majority of studies were case only. Nineteen (14.4%) articles were included cohort studies, 12 (9.1%) were case control studies, and 4 (3.0%) studies were mixed qualitative and quantitative studies.

Results form: Rates and aggregation

A total of 115 (87.1%) articles presented results in the form of a rates. The rate of per 100 000 population was the most frequently used (67 articles). Other rates utilised were: per 1 000 population (2 articles); per 10 000 population (2 articles); 1 000 000 per population (1); 100 person months (1); 1 000 person years (1); 10 000 person years (7); potential years of life lost per 100 000 (1), and per 100 000 crude bed days (1). Noting that 2 articles used more than one type of rate ratio. A total of 78 (59.1%) articles were coded as using individual person level data within analysis. Twenty-five (18.9%) articles utilised data from multiple sources that was able to be linked at the level of the individual person.

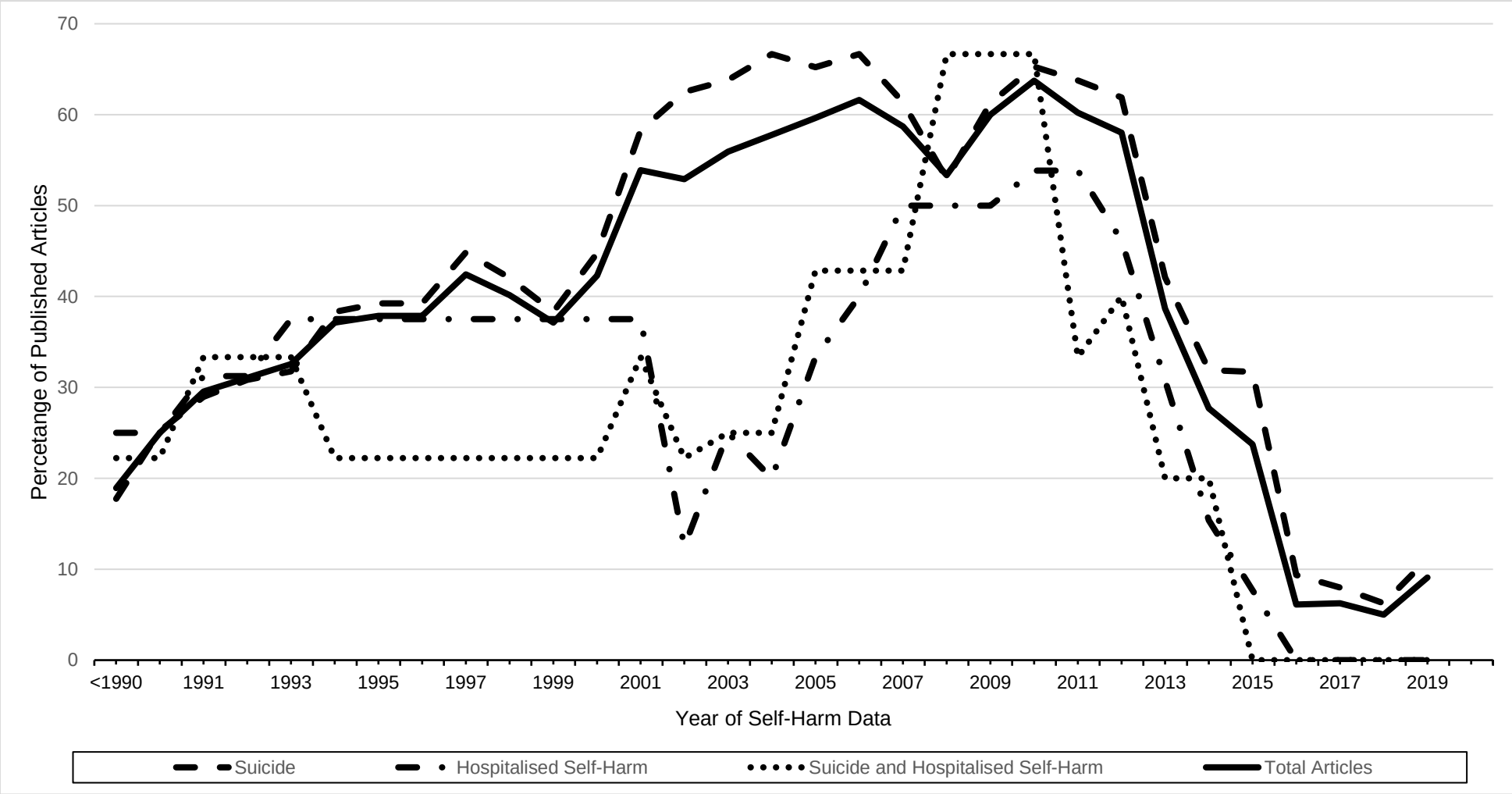
Years of self-harm data used <1990 to 2018

Figure 4 shows the percentage of all articles published from the year following the relevant year of self-harm data that then utilised suicide and/or hospitalised self-harm data for each year. For example, the 2005 suicide data graph point shows the percentage (65.3%) of suicide focused articles published 2006-2020 and used 2005 data. Year of self-harm data could indicate hospital admission or discharge, it could also indicate year of suicide death or the year that a suicide death was registered. There appear to be a relative underutilisation of 2002-2005 data in hospitalised self-harm focused articles; and a relatively

high utilisation of 2001-2012 data (with the possible exception of 2008) by authors of articles focused on suicide. There is a steep reduction in the percentage of publications, regardless of self-harm focus, using data from more recent years (particularly post 2012). This could reflect increasing difficulties in accessing data on suicide and self-harm, but is as (or perhaps more) likely to reflect the significant time lag between date of death, date of data availability, and date of publication.

Figure 4.

Years of Self-Harm Utilised



Level of geography used and geographic coverage across Australia

Table 3 includes counts for the smallest level of geography used within each article, by self-harm focus of articles (and for total articles). It is clear that State or Territory level data followed by data aggregated Australia wide are most frequently utilized. Smaller levels of geography are used relatively infrequently. Figure 5 shows the numbers of articles published using smaller, State or Territory, or Australia wide level of geographies by year. No clear pattern is apparent.

Table 3

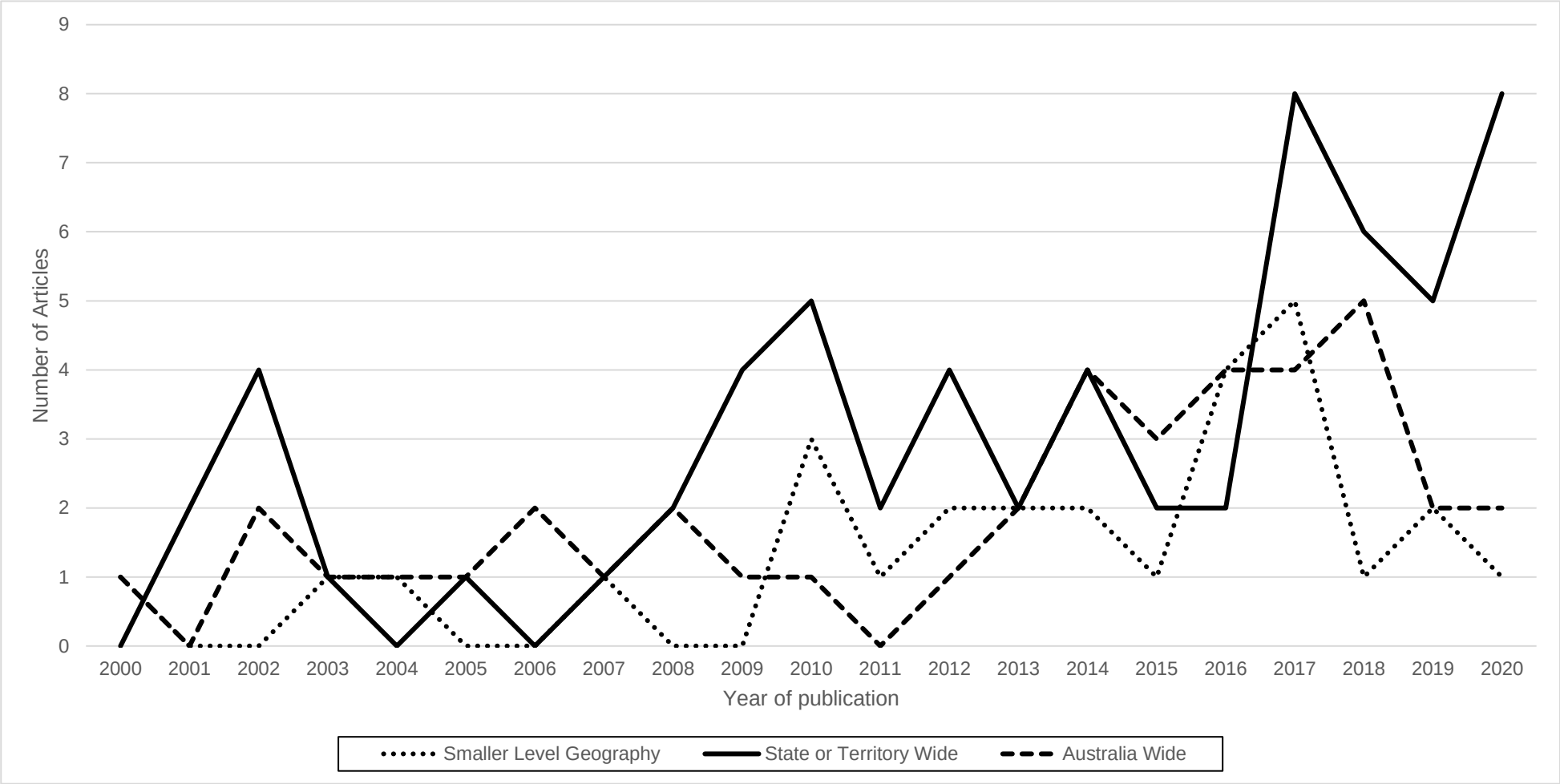
Smallest Level of Geography used by Self-Harm Focus of Articles

Level of Geography*	Self-Harm Focus			
	Suicide n	Hospitalised Self-Harm n	Suicide and Hospitalised Self-harm n	Total n(%)
Australia wide	39	0	1	40 (30.3)
State and/or Territory	47	11	5	63(47.7)
City level	5	0	0	5(3.8)
Indigenous Community	0	1	0	1(0.8)
Health Service Area	3	4	1	8(6.1)
Local Government Area	1	0	0	1(0.8)
Postal Area	5	0	1	6(4.5)
statistical Area Level 2	1	0	1	2(1.5)
Statistical Area Level 4	2	0	0	2(1.5)
Statistical Divisions	1	0	0	1(0.8)
Statistical Local Area	2	0	0	2(1.5)
Unclear	1	0	0	1(0.8)

* Smallest level if multiple used.

Figure 5

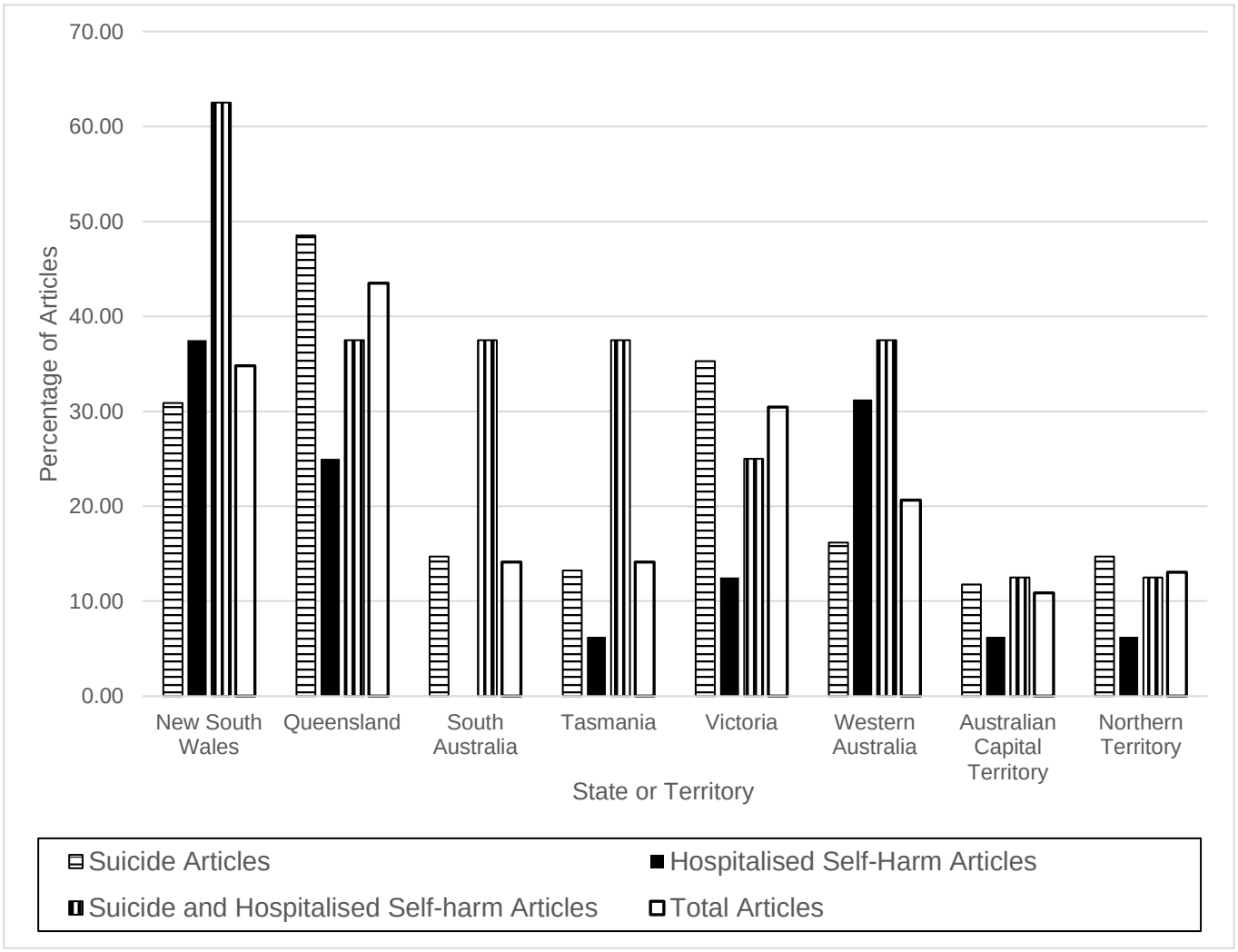
Smallest Level of Geography used by Year of Publication



Data displayed in figure 6 does not include that from articles in which the smallest level of geography used was Australia wide. Descriptively, it appear that data from Queensland has been used in the greatest proportion of total articles, followed by New South Wales, and then Victoria. New South Wales data is utilized in the greatest proportion of articles focused on hospitalised self-harm, and on both suicide and hospitalised self-harm. Data from Queensland is used in the greatest proportion of studies focused on suicide; followed by Victoria, and then by New South Wales. Data from the Australian Capital Territory and the Northern Territory are included in the lowest proportion of articles (regardless of self-harm focus).

Figure 6

Percentage of Articles Utilizing data from each State and Territory



Population characteristics of interest

Table 4 displays the primary population characteristic of interest to article authors. Population characteristic of interest were extracted from the study aims as articulated by article authors. Each article was primarily coded to only one population characteristic (;see table note regarding age). Occupations of interest were: farmer or related (5 articles), health care professionals (2 articles), higher or lower skilled occupations (2), higher or lower stress occupations (1), male or female dominated occupations (1), employees exposed to pesticides (1), veterinarians and vet nurses (1), emergency and protective services (1), construction industry (1), and one study investigated the impact of being employed. Age groups of interest (including where article authors selected subjects because of age an additional characteristic) were: children (2), adolescents (5), young people (4), young adults (6), and older adults (6). Specific health statuses of interest to article authors were: mental ill-heath or alcohol or other drug use (11), HIV positive status (1), dementia (1), major trauma patients (1), prostate cancer (1), recently given birth (1).

Table 4.

Primary Population Characteristic of interest by Self-Harm Focus

Primary Population Characteristic of Interest	Self-Harm Focus			
	Suicide n	Hospitalised Self-Harm n	Suicide and Hospitalised Self-harm n	Total n (%)
Aboriginal and Torres Strait Islander status	6	3	1	10(7.6)
Age*	9	3	1	13(9.8)
Forensic status	3	2	0	5(3.8)
Gender	6	0	0	6(4.5)
General population – no specific characteristic of interest	44	3	5	52(39.4)
Health status	11	4	1	16(12.1)
Interpersonal violence experience	2	1	0	3(2.3)
Migrant status	2	0	1	3(2.3)
Occupation type or skill level	16	0	0	16(12.1)
Other (nursing home residents, missing people, homeless people)	3	0	0	3(2.3)
Resident level of remoteness	5	0	0	5(3.8)

*where study aims articulate an interest in participants on the basis of age AND another characteristic, these studies have not been counted within the 'age' characteristic of interest group in table 4. Instead they have been grouped with the other characteristic of interest to authors. Ten articles fell into this category: 4 studies addressed age and gender, 2 addressed age and Aboriginal or Torres Strait Islander Status, 2 addressed age and experience of interpersonal violence, 2 addressed age and health status, 1 addressed age and forensic status, and 1 addressed age and nursing home residence.

Quantitative analyses utilised

The inferential analysis used within reviewed articles were, largely, grouped into themes. Where no inferential analyses were used, this was noted. The ‘Differences between Groups’ included: analysis of variance (ANOVA), binomial tests, chi-squared tests, Cohen's K tests, Fishers exact likelihood test, Mantel–Haenszel tests, t-test, Wilcoxon Mann-Whitney tests, Z-tests, and comparisons between two groups which were not further specified.

The ‘Relationship between Predictor and Outcome Variable(s)’ group included: correlations, joinpoint regression, linear regression, logistic regression, negative binomial regression, non-parametric spline curve regression, Poisson regression, and regression analysis that was not further specified. The ‘Survival Analysis on Time to Event Data’ included: competing risk regression, Cox hazards regression, ‘flexible parametric survival analysis’, Kaplan-Meier survival analyses, life-table analysis, log-rank survival analysis, and survival plots using proc phreg (SAS Command). The ‘Clustering Analysis’ group included: canonical discriminant analysis, factor analysis, scan statistics, and ‘two-stage cluster analysis’. The ‘Time Series Specific Analyses’ group included: seasonal decomposition analysis, spectral analysis, and ‘standard time series methodology’. Finally, dynamic systems modelling and Bayesian hierarchical modelling were not grouped into analysis themes. Table 5. Displays the number of articles using Quantitative Analyses within each Inferential Analysis Theme, by Spatiotemporal Focus.

Table 5.

Number of Articles using Quantitative Analyses within each Inferential Analysis Theme, by Spatiotemporal Focus.

Inferential Analysis Theme	Spatiotemporal Focus of Articles				
	Temporal n	Spatial n	Spatiotemporal n	Other n	Total n(%)
No Inferential Analyses	13	0	0	7	20 (15.2)
Differences Between Groups	16	2	0	21	39 (29.5)
Relationship between Predictor and Outcome Variables	40	3	3	28	74 (56.1)
Survival Analysis on Time to Event Data	13	0	0	0	13 (9.8)
Clustering Analyses	1	4	4	2	11 (8.3)
Time Series Specific Analyses	4	0	0	0	4 (3.0)
Dynamic Systems Modelling	2	0	0	0	2 (1.5)
Bayesian Hierarchical Modelling	0	1	0	0	1 (0.8)

Temporal articles

Table 6. documents the number of articles using quantitative analyses within each inferential analysis theme, by temporal subgroup. Temporally focused articles utilised analyses in the ‘Relationship between Predictor and Outcome Variables’ theme most commonly; with 58.8% of all temporally focused articles including at least one. A notably large proportion, 19.1%, of temporally focused studies used no interferential analyses. Table 7. shows the number temporally focused articles using each specific statistical analysis within the ‘Differences between Groups’ theme. Chi-Squared tests were used in 19.1% of

temporally focused articles and was the most frequently used statistic within this theme. Table 8 provides a more detailed summary of the specific 'Relationship between Predictor and Outcome Variables' analyses used by authors of temporally focused articles. Poisson Regression, Negative Binomial Regression, and Logistic Regression were the most frequently used analyses; utilised in 20.6%, 17.6%, and 14.7% of temporally focused articles respectively. Analyses within the 'Survival Analysis on Time to Event Data' theme were only used within cohort follow-up subgroup articles. Nine articles (13.2% of all temporal articles) included Cox Hazards Regression analyses; 4 (5.9%) Kaplan –Meier Survival analyses; 3 (4.4%) Log-Rank Survival analyse; 1 (1.5%) life-table analysis; 1 (1.5%) log-rank survival analysis, and 1 (1.5%) included survival plots using proc phreg (SAS Command). Four temporally focused articles included 'Time Series Specific Analyses'; three of these articles fell within 'More than two data time points with exposure/intervention' subgroup and utilised spectral analysis 1 (1.5%), 'standard time series methodology' 1 (1.5%), and seasonal decomposition analysis 1 (1.5%). The fourth article fell within the 'a more than two data time points with exposure/intervention' study and also utilised spectral analysis 1 (1.5%).

Table 6.

Number of Articles using Quantitative Analyses within each Inferential Analysis Theme, by Temporal Subgroup.

Inferential Analysis Theme	Temporal Subgroup				
	Cohort follow-up n	More than two data time points with no exposure/intervention n	More than two data time points with exposure/intervention n	Two data time points - with exposure/intervention n	Total n(%)
No Inferential Analyses	1	11	1	0	13 (19.1)
Differences Between Groups	6	7	3	0	16 (23.5)
Relationship between Predictor and Outcome Variables	11	17	10	2	40 (58.8)
Survival Analysis on Time to Event Data	13	0	0	0	13 (19.1)
Clustering Analyses	0	1	0	0	1 (1.5)
Time Series Specific Analyses	0	3	1	0	4 (5.9)
Dynamic Systems Modelling	0	0	2	0	2 (2.9)
Bayesian Hierarchical Modelling	0	0	0	0	0 (0.0)

Table 7

Number of Articles using Differences between Group Quantitative Analyses, by Temporal Subgroup.

Inferential Analyses	Temporal Subgroup				
	Cohort follow-up n	More than two data time points with no exposure/intervention n	More than two data time points with exposure/intervention n	Two data time points - with exposure/intervention n	Total n(%)
ANOVA	0	0	1	0	1 (1.5)
Binomial Tests	0	1	0	0	1 (1.5
Chi-Squared Tests	4	7	2	0	13 (19.1)
Cohen's K test	1	0	0	0	1 (1.5)
Fishers Exact Test	1	0	1	0	2 (2.9)
Mantel–Haenszel Tests	0	0	0	0	0 (0.0)
T-test	2	0	0	0	2 (2.9)
Wilcoxon Mann-Whitney tests	0	1	1	0	2 (2.9)
Z-test	0	1	0	0	1 (1.5)
Not further specified	1	0	0	0	1 (1.5)

Table 8.

Number of Articles using Relationship between Predictor and Outcome Variables Quantitative Analyses, by Temporal Subgroup.

Inferential Analyses	Temporal Subgroup				
	Cohort follow-up n	More than two data time points with no exposure/intervention n	More than two data time points with exposure/intervention n	Two data time points - with exposure/intervention n	Total n(%)
Correlations	0	3	1	0	4 (5.9)
Joinpoint Regression	0	3	0	0	3 (4.4)
Linear Regression	3	2	0	1	6 (8.8)
Logistic Regression	6	4	0	0	10(14.7)
Negative Binomial Regression	3	4	5	0	12 (17.6)
Non-Parametric Spline Curve Regression	1	0	0	0	1 (1.5)
Poisson Regression	1	7	5	1	14 (20.6)
Regression - Not Further Specified	0	1	0	0	1 (1.5)

Spatial articles

Table 9 shows the number of articles using quantitative analyses within each inferential analysis theme, by spatial subgroup. In contrast to temporally focused studies, none of spatially focused studies used descriptive statistics only. However, there are far fewer spatially focused studies. All spatially focused articles using ‘Cluster Analysis’ theme methods, utilised Scan Statistics. One article within the ‘spatial clustering and differences between cluster and non-cluster’ spatial subgroup used both Chi-Squared tests and Fishers Exact test (which fall within the ‘Differences between Groups’ analytic theme). One ‘differences based on spatially constructed variables’ subgroup article within the same spatial subgroup used both T-Test and Chi-Squared analyses (which fall within the ‘Differences between Groups’ analytic theme). Another article within the same subgroup used both Logistic and Poisson regressions (which fall within the ‘Relationship between Predictor and Outcome Variables’ analytic theme). Both articles within the ‘associations with spatially constructed variables’ subgroup ‘Relationship between Predictor and Outcome Variables’ analytic theme analyses. One of these articles used Poisson Regression and the other used Negative Binomial Regression.

Spatiotemporal articles

Table 10 shows the number of articles using quantitative analyses within each inferential analysis theme, by spatiotemporal subgroup. The only specific type of ‘Cluster Analysis’ used within spatiotemporal subgroups was scan statistics. The only specific ‘Relationship between Predictor and Outcome Variables’ analyses utilised within ‘spatiotemporal clustering and differences between clusters and non-clusters’ articles was logistic regression. Negative binomial regression was used within the ‘differences based on spatiotemporally constructed variables’ subgroup article.

Table 9.

Number of Articles using Quantitative Analyses within each Inferential Analysis Theme, by Spatial Subgroup.

Inferential Analyses	Spatial Subgroup				
	Spatial clustering n	spatial clustering and differences between cluster and non-cluster n	differences based on spatially constructed variables n	associations with spatially constructed variables n	Total n(%)
No Inferential Analyses	0	0	0	0	0 (0.0)
Differences Between Groups	0	1	1	0	2 (22.2)
Relationship between Predictor and Outcome Variables	0	0	1	2	3 (33.3)
Survival Analysis on Time to Event Data	0	0	0	0	0 (0.0)
Clustering Analyses	2	2	0	0	4 (44.4)
Time Series Specific Analyses	0	0	0	0	0 (0.0)
Dynamic Systems Modelling	0	0	0	0	0 (0.0)
Bayesian Hierarchical Modelling	1	0	0	0	1 (11.1)

Table 10

Number of Articles using Quantitative Analyses within each Inferential Analysis Theme, by Spatiotemporal subgroup

Inferential Analyses	Spatial Subgroup			
	Spatial clustering n	spatial clustering and differences between cluster and non-cluster n	differences based on spatially constructed variables n	Total n(%)
No Inferential Analyses	0	0	0	0 (0.0)
Differences Between Groups	0	0	0	0 (0.0)
Relationship between Predictor and Outcome Variables	0	2	1	3 (60.0)
Survival Analysis on Time to Event Data	0	0	0	0 (0.0)
Clustering Analyses	1	3	0	4 (80.0)
Time Series Specific Analyses	0	0	0	0 (0.0)
Dynamic Systems Modelling	0	0	0	0 (0.0)
Bayesian Hierarchical Modelling	0	0	0	0 (0.0)

Scan Statistics

Scan statistics, a specific clustering statistics method, was used in eight of the 14 spatial or spatiotemporal articles reviewed. Key details about the scan statistic methodology and particular specifications used within each of these articles is outline in Table 11. Scan statistics analyses were specific to spatial or spatiotemporally focused articles, and was not used within any temporally nor 'other' focused articles. Too, Pirkis, Milner, & Spittal, (2017) used scan statistics to examine spatial-temporal clustering of both deaths and hospitalisations resulting from intentional self-harm. Torok et al. (2017) used scan statistics to investigate spatial only clustering of deaths and hospitalisations resulting from intentional self-harm. The remaining articles utilizing scan statistics addressed intentional self-harm deaths only, clustered spatially or spatial-temporally.

SaTScan[1] scan statistics is used to detect and evaluate clusters of case either temporally, spatially, or spatial-temporally (Kulldorff & Information Management Services, Inc, 2021; Kulldorff, 2021). Only one article within this review investigated purely temporal clusters of suicidal behaviour; though they also tested for purely spatial and spatial-temporal clusters (Too, Pirkis, Milner, Bugeja, & Spittal, 2017). The detection of clusters is done by gradually scanning a window across space and/or time, noting the number of observed and expected observations inside the window at each location. The window with the maximum likelihood is most likely to be a cluster, that is, least likely to have occurred by chance, and is assigned a p-value. Depending of the nature of the data researchers can implement different probability models. Author for all of the articles currently under review, and made use of SatScan, implemented a Poisson model.

The authors of all articles implementing scan statistics used the SaTScan software package. SatScan is a software designed specifically for scan statistics. Torok et al. (2017) used the Hot Spot Analysis (Getis-Ord Gi*) tool in addition to SaTScan. MapInfo (Qi & Hu., 2010), ArcGIS (Cheung et al., 2013; Robinson et al., 2016; Too, Pirkis, Milner, Bugeja, & Spittal, 2017; Too, Pirkis, Milner, & Spittal, 2017; & Torok et al., 2017), and R (Hill et al., 2020) software were used to calculate coordinates for the centroids for the spatial unit of analysis and generate the mapped display of results.

SatScan's spatial only scan imposes circular or elliptic spatial window on the map. For all studies under review the scan window was circular and was in turn centred of the

[1] SaTScan™ is a trademark of Martin Kulldorff. The SaTScan™ software was developed under the joint auspices of (i) Martin Kulldorff, (ii) the National Cancer Institute, and (iii) Farzad Mostashari of the New York City Department of Health and Mental Hygiene.

centroid (crude or population weighted) for each of the spatial units (ie. Local government areas, statistical area levels, postal areas ect). The radius of the window also varies continuously in size from zero to an upper limit/s specified by the researcher. This upper limit can be defined as geographical radius distance, as a percent of the study population, or as a percent of some other specified population. The maximum radius set by authors of the reviewed studies varied as outlined in table 11.

SatScan defines the spatial-temporal (or space-time) scan statistic using a cylindrical window, with circular or elliptic base, and a height corresponding to the time dimension. All studies reviewed that used SaTScan space-time analysis implemented a circular spatial window. The maximum size of the base is defined in the same way as the spatial only scan window. The minimum and maximum temporal lengths are set by the research, and can be defined as a percentage of the whole study period, day, months or years. The cylindrical window is this then moved through time and space. For each possible geographic location (defined centroid) and size, it also visits each possible time period.

Getis-Ord Gi* hot spot analysis (ArcGIS Pro 2.7, 2021; Getis & Ord, 1992; Ord & Getis, 1995) was used by authors of one reviewed article, Torok et al. 2017, who described it as a scan statistic. This tool looks at a feature of the data (i.e. suicide deaths occurring within a particular geographic area) in the context of neighbouring features. The sum of feature and its neighbours is compared to the sum of all features. When this local sum is very different from the expected local sum and too large to be the result of random chance, a statistically significant z-score results. Results are adjusted to account for multiple testing and spatial dependency.

Torok et al. (2017) undertook Hot Spot Analysis using Getis-Ord Gi* and Spatial Cluster analysis using SaTScan. They do so, in part, to assess differences in their utility for identifying clustering and hot-spots. However, no conclusions are provided by the authors regarding potential differential utility of each tool. These authors also devised a method for using the results of both to compute a single composite score for each SA2 area.

Table 11.

Key Methodological Specifications for Articles using Scan Statistics.

Authors	Spatial units	Centroid Method	Scan statistics software	GIS software	SaTScan maximum spatial scan window radius	SaTScan temporal scan window	SaTScan probability model	All population suicide deaths	by sex	by age
Cheung et al., 2013	Australia wide PA**	unclear	SaTScan	ArcGIS	10%, 25% and 50% total population.	fixed at 1, 2, or 3 months	discrete Poisson	X		
Hill et al., 2020	Australia wide excluding SA*	R - ggmap package	SaTScan	unclear	100km. 10% population.	min 7 days max 730 days	discrete Poisson	10-24 yrs old only		
Qi et al., 2010	QLD LGA	crude area centroid	SaTScan	MapInfo	200km, 400km. 10%, 25% and 50% total population.		discrete Poisson	X	X	
Qi et al, 2012	Australia wide SLA*	unclear	SaTScan	ArcGIS	100km, 400km. 10%, 25% and 50% total population.		discrete Poisson	X	X	15-34yrs, 35-54yrs.
Robinson et al., 2016	Australia wide PA*	unclear	SaTScan	ArcGIS	maximum suicide rate within postcodes		discrete Poisson	X		<25yrs, 25+yrs

Authors	Spatial units	Centroid Method	Scan statistics software	GIS software	SaTScan maximum spatial scan window radius	SaTScan temporal scan window	SaTScan probability model	All population suicide deaths	by sex	by age
Too, Pirkis, Milner, Bugeja, & Spittal, 2017	VIC PA	crude area centroid	SaTScan	ArcGIS	maximum rate within spatial unit areas	min 1 max 12 months	discrete Poisson	Railway suicide deaths only.		
Too, Pirkis, Milner, & Spittal, 2017	WA SLA	population weighted	SaTScan	ArcGIS	maximum rate within spatial unit areas	min 1 max 12 months	discrete Poisson	X		
Torok et al., 2017	NSW SA2	unclear	SaTScan & Getis-Ord Gi*	ArcGIS	10%, 20% and 50% of the total population		discrete Poisson	X		

Neither temporally nor spatially focused articles

Table 12 outlines shows that number of articles using analyse included within each inferential analysis theme, by ‘other’ subgroup. The ‘other’ article focus theme includes all articles that do not have a temporal, spatial, or spatiotemporal focus when analysing self-harm data. Articles that addressed difference in self-harm between subgroups or a subgroup and the broader population, primarily utilised analyses within the ‘Differences Between Groups’, and ‘Relationship between Predictor and Outcome Variable’ themes. One of these articles used clustering analysis (factor analysis). Three articles were primarily data quality investigations, and none utilised inferential analyses. Additionally, four articles describing characteristics and circumstances of self-harm used no Inferential Analyse. Three articles describing characteristics and circumstances of self-harm used analysis within the ‘Differences Between Groups’ theme; four used ‘Relationship between Predictor and Outcome Variable’ theme, and one used a Cluster Analyses strategy (two-stage cluster analysis).

Table 13 shows that for articles addressing differences in self-harm between subgroups or a subgroup and the broader population; Chi-Squared test (13) is clearly the most frequently utilized specific ‘Differences Between Group’ theme analysis used. Table 14 shows that logistic regression is clearly the most frequently used specific ‘Relationship between Predictor and Outcome Variable’ analysis used for this subgroup of articles. Tables and 13 and 14 also show which specific ‘Differences Between Group’ and ‘Relationship between Predictor and Outcome Variable’ analyses were used by authors of ‘describe characteristics and circumstances’ subgroup articles.

Table 12.

Number of Articles using Quantitative Analyses within each Inferential Analysis Theme, by 'Other' Subgroup

Inferential Analysis Theme	'Other' Subgroup			
	differences between subgroups or a subgroup and the broader population	data quality investigation	describe characteristics and circumstances	All 'Other' articles
	n	n	n	n (%)
No Inferential Analyses	0	3	4	7 (14.0)
Differences Between Groups	18	0	3	21 (42.0)
Relationship between Predictor and Outcome Variables	24	0	4	28 (56.0)
Survival Analysis on Time to Event Data	0	0	0	0 (0.0)
Clustering Analyses	1	0	1	2 (4.0)
Time Series Specific Analyses	0	0	0	0 (0.0)
Dynamic Systems Modelling	0	0	0	0 (0.0)
Bayesian Hierarchical Modelling	0	0	0	0 (0.0)

Table 13.

Number of Articles using Differences between Group Quantitative Analyses, by 'Other' Subgroup.

Inferential Analyses			
	'Other' Subgroup		
	differences between subgroups or a subgroup and the broader population n	describe characteristics and circumstances n	All 'Other' articles n (%)
ANOVA	2	0	2 (4)
Binomial Tests	0	0	0 (0)
Chi-Squared Tests	13	3	16 (32)
Cohen's K test	0	1	1 (2)
Fishers Exact Test	4	1	5 (10)
Mantel–Haenszel Tests	0	1	5 (10)
T-test	3	2	1 (2)
Wilcoxon Mann-Whitney tests	0	0	0 (0)
Z-test	2	0	2 (4)
Not further specified	2	0	2 (4)

Table 14.

Number of Articles using Relationship between Predictor and Outcome Variables Quantitative Analyses, by 'Other' Subgroup

Inferential Analyses	'Other' Subgroup		
	differences between subgroups or a subgroup and the broader population n	describe characteristics and circumstances n	All 'Other' articles n (%)
Correlations	0	2	2 (4)
Joinpoint Regression	0	0	0 (0)
Linear Regression	1	1	2 (4)
Logistic Regression	18	2	20 (40)
Negative Binomial Regression	4	0	4 (8)
Non-Parametric Spline Curve Regression	0	0	0 (0)
Poisson Regression	1	1	2 (4)
Regression - Not Further Specified	0	0	0 (0)

Discussion

Our primary aim was to describe quantitative methods used to analyse Australian, monitoring level, suicide and hospitalised self-harm data. Our secondary aims were to describe the analytic methods used specifically to investigate 1) change across time and 2) geographic variation, within suicide and hospitalised self-harm data. Study characteristics (eg. publication date, population of interest, study rationale and aims) also provide important context for the results that more directly address our review aims. Our results suggest that, between 2000 and 2020, there was a (descriptive) increase in the number of peer reviewed publications addressing the monitoring of suicide and/or hospitalised self-harm within Australia. Academic researchers clearly recognise the significance of this work and the need for its continuation. In general, there were fewer articles published that focused on hospitalised self-harm as compared to suicide; with articles published in 2017 an exception to this overall finding. Even fewer publications investigated both suicide and self-harm within the same study. Our findings are broadly consistent with Schlichthorst et al.'s (2020) review finding that more Australian peer reviewed publications focus on suicide deaths, as compared to attempted suicide or suicidal ideation. Non-fatal self-harm is one of the few known predictors of completed suicide (Bostwick et. al, 2016; Chan et al., 2016; Owens et al., 2002). Consequently, research investigating both self-harm and completed suicide is important towards improving suicide surveillance and prevention initiatives.

Under a quarter of reviewed publications included a particular focus on the mechanism of self-harm used, and approximately 45% of articles did not include any mechanism of self-harm information. The relevance of including mechanism of self-harm information may vary between studies, depending on researchers' aims. Nonetheless, restriction to means of self-harm (particularly structural restrictions for example reducing access to railway lines and bridges, as well as restrictions to pharmacological agents) are one of the best-evidenced suicide prevention approaches currently available (see systematic review: Platt et al., 2020). Therefore, it is somewhat surprising to find that more than half of reviewed publications do not include any mechanism information. We suggest that researchers carefully consider including mechanism of self-harm information.

Our review found significant delay between the occurrence of self-harm incidents and the inclusion of resultant data within the peer reviewed publications. We suggest that a steep drop in the use of post 2012 self-harm data represents an unacceptable lag time. Coronial processes for suicide deaths, necessarily have extended timeframes (ABS, October 24

2020) and it has been noted by other researchers (Arensman, 2017; Witt & Robinson, 2019) that self-harm surveillance systems experience challenges with regards to the provision of timely data. Nonetheless, greater efforts are needed to ensure that the published peer reviewed literature includes the most up to date data available. Necessary delays in the production of official self-harm statistics does not fully account for the total lag in researcher utilisation of this data.

Our review found that authors of reviewed articles rarely presented academic theory as the primary rationale for undertaking their study. Atheoretical research may describe patterns of self-harming behaviours and identify features that predict the likelihood of self-harm. However, testing and development of theory is required to progress understandings of 'why' self-harming behaviours occur, including the underlying causal mechanisms involved (Hernán et al., 2019). While remaining elusive within suicide research, even a highly accurate predictive model does not necessarily reflect causal mechanisms within the 'real world' (Li et al., 2020). Models must provide both sufficient predictive power and 'real world' causal interpretability if they are to best support self-harm prevention and intervention most effectively (Hofman et al., 2017). The aims and design of the reviewed studies focus on descriptive or predictive research. Study aims infrequently set out to investigate the causal impact of an intervention or exposure on self-harming behaviour. The very clear majority of article authors used 'case only' designs. Cohort and case-control designs, which are more able to provide information about causal inferences, were used infrequently. For ethical and pragmatic reasons, there are many research questions on the topics of suicide and self-harm that cannot be addressed using experimental manipulation and randomised control. Subsequently, researchers in this area must navigate the challenges associated with using observational data to inform causality (Cero et al., 2021; VanderWeele, 2021). Nonetheless, a refocusing on study rationale, aims, and design to allow for an emphasis on theory, causal mechanisms, and intervention outcomes is needed.

Just over half of publications reviewed included a temporal (but not a spatial) component in their analysis, which addressed changes in suicide and hospitalised self-harm across time. Comparatively few articles investigated spatial or spatiotemporal variance, at 6.8% and 3.8% respectively. There may have been a small (descriptive) increase in spatially and spatiotemporally focused articles published between 2000-2020. Nonetheless, they still represent a very small proportion of the relevant literature. Further, at 37.9%, a large minority of reviewed studies addressed neither temporal or spatial variance in suicide and/or hospitalised self-harm. Across all reviewed publications, data included were predominately

aggregated across the whole of Australia, or at the state/territory level. We suggest that study findings at this high level of spatial aggregation have limited utility for social and health program planning, evaluation, or resources allocation. Analysis of monitoring data at small, specified areas of geography and at as close to real time as possible, enables the rate and 'spread' self-injurious behaviours to be more accurately tracked (Witt & Robinson, 2019). For these reasons, we recommend greater uptake in smaller spatial and temporal units of analysis by researchers investigating population level self-harming behaviours. However, we acknowledge this recommendation comes with some important methodological and ethical considerations. Methodologically, there are uncertainties in the relationship between individual-level data and their associated geographic context (or spatial unit; Robertson & Feick, 2018). This methodological challenge can be mitigated through use of individual person level linked datasets that include spatial information. Of all reviewed articles 18.9% used individual person level linked datasets, though not all included spatial data. Ethically, the risk that individuals whose data are included within data assets or research outputs may be identifiable, needs to be carefully considered and mitigated against. Nonetheless, these concerns must be weighed with the very significant potential benefits of strengthening suicide and hospitalised self-harm intervention design and evaluation (Kirby et al., 2017).

Overall, our aim was to describe the quantitative methods used to analyse Australian, monitoring level, suicide and hospitalised self-harm data. We found that approximately 15% of publications reviewed included no inferential analysis at all. Overall, statistical analyses within the 'relationship between predictor and outcome variable' analysis theme (regression and correlation analyses) were the most frequently used (56.1% of all articles). 'Relationship between predictor and outcome variable' analyses were also the most frequently used when looking specifically at temporally focused studies and studies that were neither temporally nor spatially focused ('other' articles). For 'other' articles, logistic regression was by far the most frequent specific analysis type used. Poisson regression, followed closely by negative binomial regression and then logistic regression, were the most frequently used specific analyses in temporal studies. Overall, quantitative analyses within the 'differences between groups' analysis theme were the second most frequently used (29.5% of all articles). Predominately, 'differences between groups' theme analyses were used by authors of temporally focused or neither temporally nor spatially focused articles. As expected, 'survival analysis on time to event data' were only used by temporally focused studies with a cohort follow-up design. Within the 'survival analysis on time to event data' theme, cox hazard regression analysis was most frequently used, followed by Kaplan-Meier survival analysis, and then log-rank survival analysis. Articles including 'time-series specific analyses'

accounted for only 3% of all reviewed articles and only 5.9% of all temporally focused articles.

Clustering analyses were predominately (though not exclusively) utilised within spatially or spatiotemporally focused articles. Scan statistics was, overall, the most frequently used specific clustering analysis and were used exclusively by authors of spatially or spatiotemporally focused articles. Overall, only a relatively small number of studies (8) used scan statistics, and all were from the second half of the reference period, with publication dates between 2012 and 2020. Scan statistics one of the few tools to date that have been used to interrogate suicide and hospitalised self-harm data at smaller spatial and temporal units of analysis. Scan statistics and other available population level spatiotemporal visualization and analytical tools (see review: Blangiardo et al, 2020; & Kanankege et al.,2020), may facilitate research outcomes that are more readily actionable for policy development and service planning purposes.

With the exception that a notable minority of authors used previously linked data assets, analytic methods commonly associated with 'data science' were largely absent from the articles we reviewed. These 'data science' methods include machine learning, natural-language processing (for example of electronic health records), data mining, and forecasting (Wulz et al., 2021). Wulz et al. (2021) competed a systematic review and concluded that data science tools can be used to describe suicidal thoughts or behaviour, identify risk factors for self-harm, and predict self-harm outcomes. Wulz et al's review did not include any population level studies using Australian data, which is consistent with our current findings. Notably, Wulz et al did not conceptualise data science methods as contributing to causal inference. Nonetheless, recent efforts have been made to (re)orient use of 'data science' methods towards the determination of causal inference from observational data (Hernán et al., 2019). We acknowledge that, caution is warranted when considering applications of data science methods that have the potential to perpetuate structural societal inequalities. However, this caution does not justify the neglect of a potentially fruitful avenue for research using suicide and self-harm monitoring data. Data science methods can be used with appropriate ethical considerations. For example, Valdivia et al. (2021) investigated the use of equitable algorithms in machine learning and quantified the associated trade-off between accuracy and fairness. Our review appears to have identified a dearth of research applying quantitative data science methods to Australian suicide and self-harm monitoring data. We recognise that, to date, studies using machine learning to predict suicide outcomes for individuals have not yielded policy or clinically meaning results (Belsher et al., 2019).

Nonetheless, it is possible that applying these tools at population level (rather than individual level), with meaningful temporal and spatial specificity, may more readily provide policy relevant information.

Page, Atkinson, Campos, et al (2018) and Page, Atkinson, Heffernan, et al. (2018), both used a dynamic system modelling approach. None of the other articles reviewed used analytic tools associated with complex systems science (Siegenfeld & Bar-Yam, 2020). Systems modelling and simulation are two complex systems tools that are now routinely used to forecast disease behaviour, quantify uncertainty, and inform public health response to infectious diseases (for reviews see: McGill et al., 2021; Walters et al, 2018). While limited efforts have been made, sophisticated use of these tools to understand the complex interactions and contingencies leading to intentional self-harm in Australia (or internationally), has not been realised (Atkinson et al. 2020). We suggest that researchers using Australian self-harm monitoring data consider the potential benefits of analytic methods originating from complex systems science.

Limitations

With any scoping review, it is necessary to restrict focus to make the analysis tractable. The limitations of this review must be considered when interpreting our results. One intentional restriction has been to focus on literature with data on Australia. Doing so has highlighted that there are very few studies that contain both Australian data and data from other countries. Another limitation in the scope has been to limit self-harm to hospitalisation, which has the potential bias findings against those who live in remote areas or who would otherwise have less access to hospitals. This is likely to have reduced studies that have a focus on Aboriginal and Torres Strait Islander Australians.

Methodologically, the project has been limited by a single exporter of data. While a second author has been involved in the data extraction process where there is uncertainty around the coding, inevitably the assumptions of the coding author will feed into the results. The current scoping review does not report on the data sources used nor on the definitions of suicide and self-harm used within the academic literature. Clearly defining the criteria by which individuals are identified as having died by suicide or having experienced self-harm are fundamental for the robustness of any monitoring system (Witt & Robinson, 2019) and any research that is subsequently undertaken utilising the monitoring data. It is crucial that academic researchers understand and report on this aspect of the data they use. This is important for replicability and comparison of results across different studies (both within

Australia and internationally). As an example, the Australian Bureau of Statistics reports suicide deaths by the year in which the death was registered and also by the year in which the death occurred. Furthermore, for suicide deaths that were registered from 2007 onwards, data are released in three iterations as preliminary, revised, and finalised data. While out of scope for current review, we highlight these non-trivial complexities in case inclusion and data structure as a reminder for researchers to give them close consideration and also because we suggest that investigating their true impact on the academic literature is worthy of future investigation.

Conclusion

Between 2000-2021, there has been an overall increase in the number of peer reviewed publications addressing Australian suicide and/or hospitalised self-harm. However, hospitalised self-harm is under investigated when compared to self-harm resulting in death. More than half of reviewed publications do not include any mechanism or method of self-harm information. There is a significant delay between the generation of self-harm statistics and utilisation of that data by academic researchers. The very clear majority of article authors used ‘case only’ designs and authors rarely presented academic theory as the primary rationale for undertaking their study. Cohort and case-control designs, which are more able to provide information about causal inferences, were used infrequently. Few articles reviewed investigated spatial or spatiotemporal variance of hospitalised self-harm and suicide. Scan statistics were, by far, the most frequently used analytical techniques used by authors of spatially or spatiotemporally focused articles. Of all articles reviewed, very few included analytic methods associated with data science and complex systems science. Researchers using Australian self-harm monitoring data ought to reflect on the analytic strategies that have been used to date within the peer reviewed literature when formulating their future research agendas.

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Appendix A: Full Search Strategy

ProQuest (Central)

[STRICT] (((TI(suicides)) OR TI(suicide) OR ((TI(suicidal) OR TI(attempt* NEAR/1 suicide) OR TI("self-injur*") OR TI("self injur*") OR TI("self-harm") OR TI("self harm")) AND ((TI,AB(death) OR TI,AB(mortality) OR TI,AB(letha*) OR TI,AB(fata*)) OR ((TI,AB(hospitalisation) OR TI,AB(hospitalization)) OR (TI,AB(hospital) AND (TI,AB(admission) OR TI,AB(discharge) OR TI,AB(separation))))))) AND ((SU(surveil*) OR SU(monitor*) OR SU(epidemiolo*) OR SU("population") OR SU("public health"))) AND LOC(Australia))

Point and click applied filters*:* Peer Review, Scholarly Journal 2000- 2020, English

Web of Science (core Collection)

((((((((((((((((TI=suicides)) OR (((TI=(attempt* NEAR/1 suicide) OR TI=suicidal OR TI=suicide OR TI="self-injur*" OR TI="self injur*" OR TI="self-harm" OR TI="self harm"))) AND (((TS=death OR TS=mortality OR TS=lethal* OR TS=fatal*) OR (TS=hospitalisation OR TS=hospitalization) OR (TS=hospital AND (TS=admission OR TS=discharge OR TS=separation))))) AND ((((((AK=surveil* OR AK=monitor* OR AK="public health" OR AK=population OR AK=epidemiolog*)))))))))))))))) AND ALL=Australia)))

Point and click applied filters*:* English; publication year 2000-2020, restricted document types to: article, review, early access, and correction. Excluded: proceedings paper, editorial material, book chapter, letter

PubMed

("suicides"[Title] OR "suicide"[Title] OR ("attempted suicide"[Title] OR "suicidal"[Title] OR "suicide attempt"[Title] OR "self injur*"[Title] OR "self injur*"[Title] OR "self-harm"[Title] OR "self-harm"[Title])) AND ("death"[Title/Abstract] OR "mortality"[Title/Abstract] OR "lethal*"[Title/Abstract] OR "fatal*"[Title/Abstract] OR ("hospitalisation"[Title/Abstract] OR "hospitalization"[Title/Abstract]) OR ("hospital"[Title/Abstract] AND ("admission"[Title/Abstract] OR "discharge"[Title/Abstract] OR "separation"[Title/Abstract]))) AND ("surveil*"[Title/Abstract] OR "monitor*"[Title/Abstract] OR "public

health"[Title/Abstract] OR "population"[Title/Abstract] OR "epidemiolo*"[Title/Abstract]) AND ("australia"[MeSH Terms] OR "australia"[All Fields])

Point and click applied filters*:* English; publication year 2000-2020.

PsycINFO

(suicides.m_titl. or suicide.m_titl. or ((attempt* N1 suicide or suicidal or ""self-injuri*"" or ""self injur*"" or ""self-harm"" or ""self harm"").m_titl. and (death or mortality or lethal* or fatal* or (hospitalisation or hospitalization) or (hospital and (admission or discharge or separation))).id,sh.)) and (surveil* or monitor* or ""public health"" or population or epidemiolo*).id,sh. and Australia.lo.

Point and click applied filters: English; publication year 2000-2020, Peer reviewed journal

Appendix B: Articles Included in Scoping Review

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