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Efficacy of the Zero Suicide framework in reducing recurrent suicide attempts: cross-sectional and time-to-recurrent-event analyses

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Background

The Zero Suicide framework is a system-wide approach to prevent suicides in health services. It has been implemented worldwide but has a poor evidence-base of effectiveness.

Aims

To evaluate the effectiveness of the Zero Suicide framework, implemented in a clinical suicide prevention pathway (SPP) by a large public mental health service in Australia, in reducing repeated suicide attempts after an index attempt.

Method

A total of 604 persons with 737 suicide attempt presentations were identified between 1 July and 31 December 2017. Relative risk for a subsequent suicide attempt within various time periods was calculated using cross-sectional analysis. Subsequently, a 10-year suicide attempt history (2009–2018) for the cohort was used in time-to-recurrent-event analyses.

Results

Placement on the SPP reduced risk for a repeated suicide attempt within 7 days (RR = 0.29; 95% CI 0.11–0.75), 14 days (RR = 0.38; 95% CI 0.18–0.78), 30 days (RR = 0.55; 95% CI 0.33–0.94) and 90 days (RR = 0.62; 95% CI 0.41–0.95). Time-to-recurrent event analysis showed that SPP placement extended time to re-presentation (HR = 0.65; 95% CI 0.57–0.67). A diagnosis of personality disorder (HR = 2.70; 95% CI 2.03–3.58), previous suicide attempt (HR = 1.78; 95% CI 1.46–2.17) and Indigenous status (HR = 1.46; 95% CI 0.98–2.25) increased the hazard for re-presentation, whereas older age decreased it (HR = 0.92; 95% CI 0.86–0.98). The effect of the SPP was similar across all groups, reducing the risk of re-presentation to about 65% of that seen in those not placed on the SPP.

Conclusions

This paper demonstrates a reduction in repeated suicide attempts after an index attempt and a longer time to a subsequent attempt for those receiving multilevel care based on the Zero Suicide framework.

Keywords

Suicide prevention; Zero Suicide framework; suicide attempt; time to event analysis; brief interventions.

Copyright and usage

The Zero Suicide framework in healthcare is a system-wide approach to care after a suicide attempt with the goal that no suicides should occur when a person is in contact with the health service.[1] It is predicated on seven elements: lead, train, identify, engage, treat, transition and improve. These elements of clinical care rely on systematic protocols that should involve ongoing risk screening and assessment, collaborative safety planning, access to evidence-based suicide-specific care, focus on lethal means reduction, consistent engagement efforts and support during high-risk periods.[2] The Zero Suicide framework has seen a rapid adoption, having been implemented in over 200 healthcare and behavioural health organisations worldwide by 2016.[3] The Zero Suicide framework was substantially influenced by the Perfect Depression Care initiative,[4] of the Henry Ford Health System in Michigan, USA, which was shown to reduce the rate of deaths by suicide by 75% in the first 4 years of implementation.[5–7] More recently, Centerstone in Tennessee reported a 65% reduction in the rate of deaths by suicide among patients treated for a variety of psychiatric conditions after implementing the Zero Suicide framework.[3] However, initial evaluations have drawn criticism, owing to their observational nature, concerns about overstated outcomes and caution being expressed in comparing the Zero Suicide framework with the Perfect Depression Care model.[6,8] Despite the widespread rollout of Zero Suicide framework, there remains a lack of robust evidence for its effectiveness published internationally[1,6] and we are not aware of any such research from Australia.

Implementation of the Zero Suicide framework at Gold Coast Mental Health and Specialist Services, Queensland, Australia

Although the Zero Suicide framework provides an overarching framework, it does not prescribe in detail the clinical components to be implemented. At Gold Coast Mental Health and Specialist Services (GCMHSS), a clinical suicide prevention pathway (SPP) based on Zero Suicide framework was rolled out in December 2016. Table 1 illustrates the tools and interventions comprising the SPP; they are listed in the order of their use following an individual's presentation to the hospital.

A concerted focus on training all GCMHSS clinical staff in the delivery of individual components of the SPP and developing attitudes, beliefs, confidence and skills in accord with the Zero Suicide framework, alongside a strong focus on cultural change and incorporation of Restorative Just Culture principles,[9] contributed to the rapid adoption of the new practices across GCMHSS.[10]

Reports on the Zero Suicide framework's efficacy have frequently focused on deaths by suicide. However, this metric has limitations as suicide deaths are relatively rare, making it challenging to ascribe statistical significance to clinically important associations or to build models that adequately consider possible confounders. Considering that a suicide attempt is one of the greatest risk factors for suicide completion[11] and that people with a suicide attempt share substantial clinical similarities with those who die by suicide,[12] re-presentation with a suicide attempt

Table 1 Suicide prevention pathway (SPP) elements based on the Zero Suicide framework implemented at the Gold Coast Mental Health and Specialist Services

Suicide prevention pathway element	Assessment tool/Treatment	Additional details
Screening and engagement	Mental health assessment after presentation with suicidal ideation or after suicide attempt	A screening triage tool (UK Mental Health Triage Scale)[13] was implemented and embedded in the electronic medical record
Assessment	Chronological assessment of suicide events (CASE) approach	CASE is an interviewing strategy for eliciting suicidal ideation, planning, behaviour, desire and intent. It uses a range of validity techniques (e.g. normalisation, shame attenuation, gentle assumption) that help clinicians explore content that is sensitive or taboo for the patient[14]
Risk formulation	Prevention-oriented risk formulation	The formulation provides a synthesis of information gathered in a comprehensive assessment based on contextually anchored risk relative to specified subgroups (risk status) and relative to the individual's own baseline (risk state). The formulation also assesses available internal and external resources, and foreseeable changes that might lead to a change in risk[15]
Brief interventions	Safety planning intervention (SPI)[16]	The SPI, based on work by Stanley & Brown,[17] was developed for inclusion in the SPP. It includes individualised warning signs, internal coping strategies, social contacts to distract from suicidal thoughts, social and professional supports to assist with resolving suicidal crises, and strategies to restrict access to lethal means of suicide
	Counselling on access to lethal means	This counselling is contained within the SPI
	patient and carer education	A patient brochure and a family/carer brochure developed in conjunction with people with lived experience in the service are given to individuals on the SPP
Follow-up	Rapid referral	Face-to-face appointment is scheduled for patients on the SPP within 48 h of discharge from emergency department or in-patient care. This is typically performed by the clinical staff in the GCMHSS acute care team or child and youth mental health service
	Structured follow-up	Includes regular assessment of suicidality; review and revision of the safety plan; creation or updating of a care plan; and ongoing communication with family/carers and other health professionals. The number of follow-up appointments depends on the circumstances and needs of the individual and follow-ups are typically performed by the clinical staff in the GCMHSS acute care team or child and youth mental health service
Transition of care	Warm handover	A 'warm handover' means that the patient should have had their first appointment with the next provider prior to closure from GCMHSS
	Support and transition services	Transition to follow-up care in the community is supported through the collaborative development of a treatment plan and identification of any barriers to treatment

provides an alternative outcome measure for suicide intervention studies.[18,19]

The aim of this paper is to report on the efficacy of the SPP with respect to reducing re-presentations with a suicide attempt following an initial attempt. As certain subgroups have an elevated risk of repeated suicide attempts, for example those with previous attempts[20] or those diagnosed with borderline personality disorder,[21,22] the efficacy of the SPP with respect to these high-risk subgroups will be specifically explored.

A novel aspect to this work is that we embrace the fact that an individual may present with a suicide attempt multiple times. Traditional approaches limit analysis to the first subsequent event and either its occurrence within a certain time frame (relative risks or logistic regression models) or the time to that first subsequent event (e.g. Cox proportional hazards analysis). Limiting analysis to the first recurrent suicide attempt ignores both a considerable amount of information and the clinical nature of the attempt. However, recurrent events are by definition correlated, which violates the independence assumption required by traditional methods. A number of different statistical models have been developed for analysis of multiple event data. As this is a relatively new area of statistical analysis, there is no consensus on which may be the most appropriate for a given situation. In this paper, we present the results of six different models that we considered, *a priori*, to be suitable for analysis of suicide attempt events and use the consistency of their results to infer an appropriate model to predict suicide attempt recurrence. Although there is literature reporting time-to-event analyses with regard to first subsequent suicidal presentation or

suicide,[23,24] such studies are relatively uncommon, and we are unaware of other studies using time-to-recurrent-event analysis with respect to suicide attempts. However, the approach is highly relevant to suicide attempts in the evaluation of interventions that aim to delay time to re-presentation. Although novel with respect to analysis of repeated suicide attempts, time-to-recurrent-event analysis has been used in other areas of mental health research, such as self-harm.[25]

Method

Context of the project

The Gold Coast Hospital and Health Service (GCHHS) is government-funded and serves approximately 560 000 people on the Gold Coast, Queensland, Australia. The GCHHS has two emergency departments and these are the most common access points for persons presenting with suicidal thoughts or behaviours. Gold Coast Mental Health and Specialist Services (GCMHSS) within GCHHS adopted the Zero Suicide framework in 2015.

Design

This project employs two designs, an initial observational cross-sectional design and a subsequent historical cohort design. In both cases re-presentation with a suicide attempt after a previous suicide attempt is the primary outcome.

Identification of suicide attempts

Presentations following a suicide attempt between 1 July and 31 December 2017 to GCHHS emergency departments were identified from the Emergency Department Information System (EDIS). A machine learning tool 'Searching EDIS for Records of Suicidal Presentations' (SERoSP)[26] identified a total of 3417 suicidal and self-harm presentations. A team of trained research officers then reviewed the associated medical records contained in the Consumer Integrated Mental Health Application (CIMHA) and electronic medical record (eMR) to confirm suicide attempts. Cases were coded as a suicide attempt if they contained evidence of self-harming behaviour with intent to die, following literature-based definitions[27] and the World Health Organization manual on surveillance and monitoring of suicide attempts and self-harm.[28] This yielded 737 presentations with a suicide attempt, relating to 604 persons. An initial cross-sectional analysis investigated the relationship between being placed on the SPP and subsequent re-presentation with a suicide attempt within certain time frames.

For each of the 604 persons who presented with a suicide attempt between 1 July and 31 December 2017, all previous suicide attempt presentations since 1 January 2009 and subsequent suicide attempt presentations until 31 December 2018 were identified, providing a 10-year longitudinal history of suicide attempts for this cohort and including a total of 1534 suicide attempt presentations. This historical cohort data was used in a time-to-recurrent-event analysis. Analyses were based on presentations, rather than on individuals, as placement on the SPP related to a presentation rather than an individual and individuals may have presented with more than one suicide attempt within the observed time period.

Variables

For every suicide attempt event, it was recorded whether the person was placed on the SPP or not. Not all persons presenting to GCMHSS after a suicide attempt engaged with the SPP; reasons for not engaging typically included the individual declining follow-up care, residing outside the geographical catchment area or receiving follow-up from a different health service or private healthcare providers. In some cases, clinicians decide not to commence the SPP, for example owing to lack of familiarity with the protocol and confidence in the early phase of implementation, time pressures in the emergency department and clinical judgement about the likely benefits of placing someone on the SPP. Patients not commenced on the SPP after presentation with a suicide attempt may still receive certain components of the SPP and follow-up care (e.g. risk formulation, safety planning and telephone follow-up on discharge) but not the structured face-to-face follow-up that is mandated in the SPP.

Patients are typically placed on the SPP following the initial assessment by a mental health clinician in the emergency department or, when receiving in-patient care, during their admission. The date of discharge – either from emergency department or in-patient care – was considered as the starting point in the analysis of subsequent re-presentations with a suicide attempt within 7, 14, 30 or 90 days. The date of discharge was also considered when measuring the length of placement on the SPP for in-patients. On average, individuals were placed on the SPP for 15.6 days, with no significant difference in this duration between those admitted to in-patient care and those discharged following their emergency department presentation (Gold Coast Mental Health and Specialist Services, unpublished data. Note that due to strict confidentiality of this material we can not release any further details, apart from data vetted by our Ethics Committee and disseminated in peer-review publications.)

For each individual on the SPP, patient identification number, date and time of presentation, age, gender (male/female), Indigenous status (yes/no), triage notes, method of suicide attempt, destination after presentation to the emergency department (admitted to hospital for at least 24 h/discharged), and primary and secondary diagnoses according to the ICD-10-AM,[29] were extracted from EDIS. Additionally, ICD diagnostic codes (F60–F69 'Disorders of adult personality and behaviour', recorded as a primary or secondary diagnosis) at any engagement with GCMHSS were used to identify persons with personality disorders.

Statistical analysis

Descriptive statistics were used for demographic and clinical data of the person associated with each presentation. Comparisons were made between the characteristics of presentations that led to the person being placed, or not placed, on the SPP. The chi-squared (χ^2) test, Fisher's exact test or t-test were used as appropriate. Re-presentation proportions within 7, 14, 30 and 90 days were compared between initial presentations associated with being placed on the SPP or not. Relative risks and their 95% confidence intervals were calculated. All analyses were performed using Microsoft Excel and Stata 15 for Windows.

Time-to-recurrent-event analyses

Time-to-recurrent-event analyses were conducted in which suicide attempt was modelled as a recurrent event for all suicide attempt presentations from 1 January 2009 to 31 December 2018, associated with the 604 persons who presented with a suicide attempt between 1 July 2017 and 31 December 2017.

As there is no consensus on the most appropriate method for modelling recurrent events,[30–32] six models were used: (a) the Anderson–Gill counting process (AG–CP); (b) Prentice–Williams–Petersen total time (PWP–TT); (c) Prentice–Williams–Petersen gap time (PWP–GT); (d) Weibull gamma shared frailty (shared frailty); (e) multilevel mixed effects parametric (mixed effects); and (6) Cox proportional hazards shared frailty (Cox shared frailty). Details of these models and the rationale for using a variety of models are provided in the supplementary material, available at https://doi.org/10.1192/bjp.2020.190.

The predictor variable of primary interest was the person being placed on the SPP (SPP, no = 0, yes = 1). Other variables considered were gender (female = 0, male = 1), age (decades), a diagnosis of personality disorder (personality disorder, no = 0, yes = 1), Indigenous status, defined as identifying as Aboriginal and/or Torres Strait Islander (Indigenous, no = 0, yes = 1), the number of previous suicide attempts (n), method of suicide attempt (overdose = 1, other = 0), admitted to hospital (no = 0, yes = 1) and year the suicide attempt occurred (year). As a small number of persons was known to re-present many times, it was considered that this might unduly skew effect estimates of predictors in favour of the attributes of the overrepresented individuals. To test this possibility, models were run using the full data-set and then truncated at various suicide attempt presentation frequencies based on the relative contribution of events by individuals. A truncation point of 5 offered the most robust modelling of the effects of frequently re-presenting individuals while still demonstrating all factors significantly predicting time to re-presentation observed at other truncation points. This truncation point is consistent with others reported in similar time-to-recurrent-event analyses.[32]

Graphs of predicted hazards against time to re-presentation were plotted for specific values of variables associated with significant hazard ratios. The hazard is the instantaneous probability that a suicide attempt event occurs at a particular time, given that a suicide attempt has not already occurred to that time.[33] The

hazard ratio (HR) is the ratio of the hazard under one condition as compared with an alternative, e.g. being on the SPP versus not being on the SPP.

For each model type, each possible covariate was added to a model containing SPP status. Those with $P \leq 0.10$ were included in all possible combinations and retained in the final model if consistently $P < 0.05$. Plausible interactions were tested (SPP × personality disorder, SPP × Indigenous status, SPP × order (whether it was a person's first or subsequent suicide attempt) and SPP × age) and retained in the model if $P < 0.05$. Where a covariate was shown to be significant in one of the model types, it was included in all for comparison purposes. Regression diagnostics including calculation of variance inflation factors to test for collinearity were undertaken. Where appropriate, the proportional hazards assumption was checked for all covariates using Schoenfeld residuals.

Ethics and consent

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The project was recognised as a quality activity by the Gold Coast Hospital and Health Service Human Research Ethics Committee (HREC) on 10 October 2018 (reference LNR/2018/QGC/47473) and did not require consent from patients.

Results

Population description

There were 737 suicide attempt presentations between July and December 2017. Demographic and clinical characteristics of patients associated with each presentation were similar between those who were placed on the SPP and those who were not (Table 2). The exceptions were persons presenting having a diagnosis of a personality disorder and having had a previous suicide attempt. People with personality disorder were far less likely ($P = 1.5 \times 10^{-8}$) to be associated with subsequent placement on the SPP than those who did not have such a diagnosis, and people with a first suicide attempt were more likely to be placed on the SPP ($P = 0.01$).

Re-presentations with a suicide attempt: cross-sectional analysis

Persons who had a suicide attempt presentation between 1 July and 31 December 2017 were followed for 90 days; re-presentation rates within 7, 14, 30 and 90 days for persons placed on the SPP and those who were not are shown in Fig. 1. Of 444 presentations in which the person had not been placed on the SPP, 37, 50, 67 and 102 re-presented within 7, 14, 30 and 90 days respectively. Of 293 presentations in which the person had been placed on the SPP, 5, 10, 25 and 42 re-presented within 7, 14, 30 and 90 days, respectively. The relative risks of re-presentation when placed on the SPP compared with not being on the SPP were the following: within 7 days, RR = 0.29 (95% CI 0.11–0.75), $P = 0.007$; 14 days, RR = 0.38 (95% CI 0.18–0.78), $P = 0.006$; 30 days, RR = 0.55 (95% CI 0.33–0.94), $P = 0.028$; and 90 days, RR = 0.62 (95% CI 0.41–0.95), $P = 0.027$.

Time-to-recurrent-event analysis

Time-to-event analysis was conducted on 1534 suicide attempt presentations, from 1 January 2009 to the censor date of 31 December 2018. These presentations constituted a history of up to 10 years for each of the originally identified 604 persons. Results of this analysis are shown in Table 3 and Fig. 2.

The number of suicide attempt presentations for an individual was found to be a significant time-to-event predictor across each model. Specifically, the first suicide attempt was associated with a lower hazard for re-presentation, whereas all subsequent presentations were each associated with higher hazards of similar values. Consequently, the 'order' variable was dichotomised to represent either the first (1) or a subsequent (2) suicide attempt event and renamed '>1st attempt'.

In addition to the SPP, four covariates (personality disorder; >1st attempt; age; and Indigenous status) were shown to significantly influence time to re-presentation with a suicide attempt. Placement on the SPP was associated with an HR < 1.0, meaning that it reduced the probability of a repeated suicide attempt after the initial attempt to approximately 65% of that of a person not on the SPP (the range was HR = 0.568–0.675, depending on the model). Conversely, being diagnosed with a personality disorder was associated with an increased hazard for a repeated suicide attempt presentation (by up to 2.7 times) compared with a person not diagnosed with personality disorder. Having had a preceding suicide attempt in the observation period

Table 2	Description of presentations with suicide attempts July–December 2017, by placement on the suicide prevention pathway		
	On suicide prevention pathway ($n = 293$)	Not on suicide prevention pathway ($n = 444$)	P^a
Demographic variables			
Gender, n (%)			
Female	189 (64.5)	283 (63.7)	
Male	104 (35.5)	161 (36.3)	0.83
Age, years: mean (s.d.)	32.0 (15.8)	34.2 (16.1)	0.08
Indigenous status, n (%)			
Aboriginal and/or Torres Strait Islander	15 (5.1)	36 (8.1)	
Not Indigenous	278 (94.9)	408 (91.9)	0.12
Clinical variables, n (%)			
Personality disorder			
Yes	14 (4.8)	86 (19.4)	
No	279 (95.2)	358 (80.6)	1.5×10^{-8}
>1st suicide attempt, n (%)			
Yes	109 (37.2)	205 (46.2)	0.01
No	184 (62.8)	239 (53.8)	
Method, n (%)			
Overdose	180 (73.8)	276 (73.0)	
Other	64 (26.2)	102 (27.0)	0.84
Admitted to hospital, n (%)			
Yes	88 (30.0)	149 (33.6)	
No	205 (70.0)	295 (66.4)	0.32

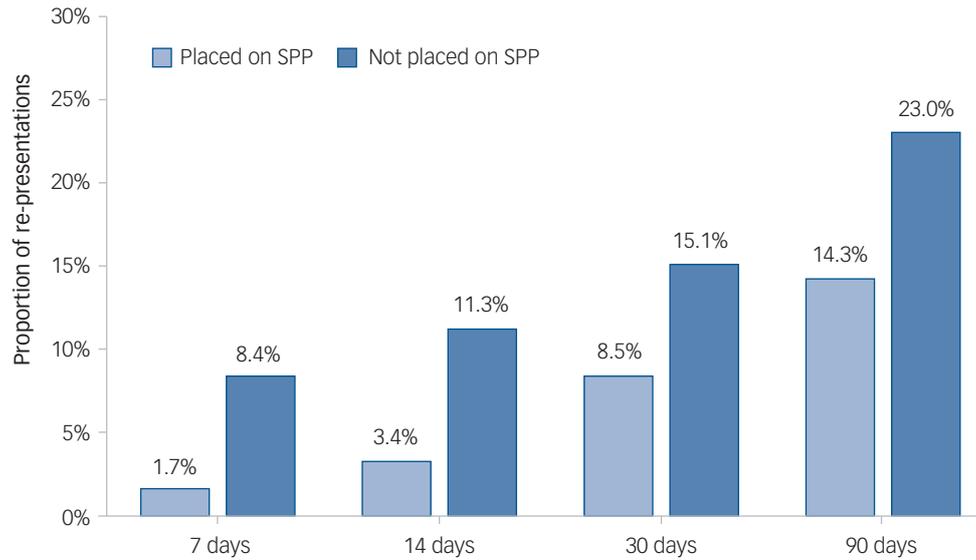a. P-values were derived from χ^2-tests or t-tests, as appropriate.

Fig. 1 Re-presentations with a suicide attempt at 7, 14, 30 and 90 days, by placement on the suicide prevention pathway (SPP).

Table 3 Hazard ratio estimates for each time-to-event model[a] considered

Model	Predictor	HR	Lower 95% CI	Upper 95% CI	P
AG–CP					
	SPP	0.643	0.511	0.809	1.63×10^{-04}
	>1st attempt	2.021	1.688	2.420	1.87×10^{-14}
	Age, decades	0.940	0.879	1.005	7.19×10^{-02}
	Personality disorder	2.056	1.595	2.649	2.55×10^{-08}
	Indigenous	1.565	1.150	2.131	4.37×10^{-03}
PWP–TT					
	SPP	0.675	0.534	0.852	9.67×10^{-04}
	>1st attempt	1.000			
	Age, decades	0.951	0.892	1.013	1.21×10^{-01}
	Personality disorder	2.104	1.688	2.622	3.59×10^{-11}
	Indigenous	1.630	1.256	2.117	2.43×10^{-04}
PWP–GT					
	SPP	0.654	0.523	0.819	2.16×10^{-04}
	>1st attempt	1.000			
	Age, decades	0.937	0.878	1.000	5.12×10^{-02}
	Personality disorder	2.065	1.639	2.601	7.27×10^{-10}
	Indigenous	1.440	1.053	1.971	2.26×10^{-02}
Shared frailty					
	SPP	0.568	0.451	0.714	1.37×10^{-06}
	>1st attempt	1.782	1.464	2.167	7.93×10^{-09}
	Age, decades	0.919	0.859	0.984	1.51×10^{-02}
	Personality disorder	2.698	2.034	3.579	5.99×10^{-12}
	Indigenous	1.456	0.983	2.157	6.15×10^{-02}
Mixed effects					
	SPP	0.570	0.451	0.721	2.73×10^{-06}
	>1st attempt	1.720	1.407	2.103	1.22×10^{-07}
	Age, decades	0.919	0.856	0.987	1.98×10^{-02}
	Personality disorder	2.826	2.098	3.806	8.49×10^{-12}
	Indigenous	1.477	0.971	2.245	6.88×10^{-02}
Cox shared frailty					
	SPP	0.652	0.514	0.827	4.16×10^{-04}
	>1st attempt	1.790	1.479	2.167	2.23×10^{-09}
	Age, decades	0.917	0.854	0.986	1.88×10^{-02}
	Personality disorder	2.718	2.043	3.616	6.42×10^{-12}
	Indigenous	1.506	0.992	2.285	5.49×10^{-02}

HR, hazard ratio; SPP, suicide prevention pathway; >1st attempt, subsequent suicide attempt presentation compared with the first; AG–CP, Anderson–Gill counting process; PWP–TT, Prentice–Williams–Petersen total time; PWP–GT, Prentice–Williams–Petersen gap time; shared frailty, Weibull gamma shared frailty; mixed effects, multilevel mixed effects parametric; Cox shared frailty, Cox proportional hazards shared frailty.
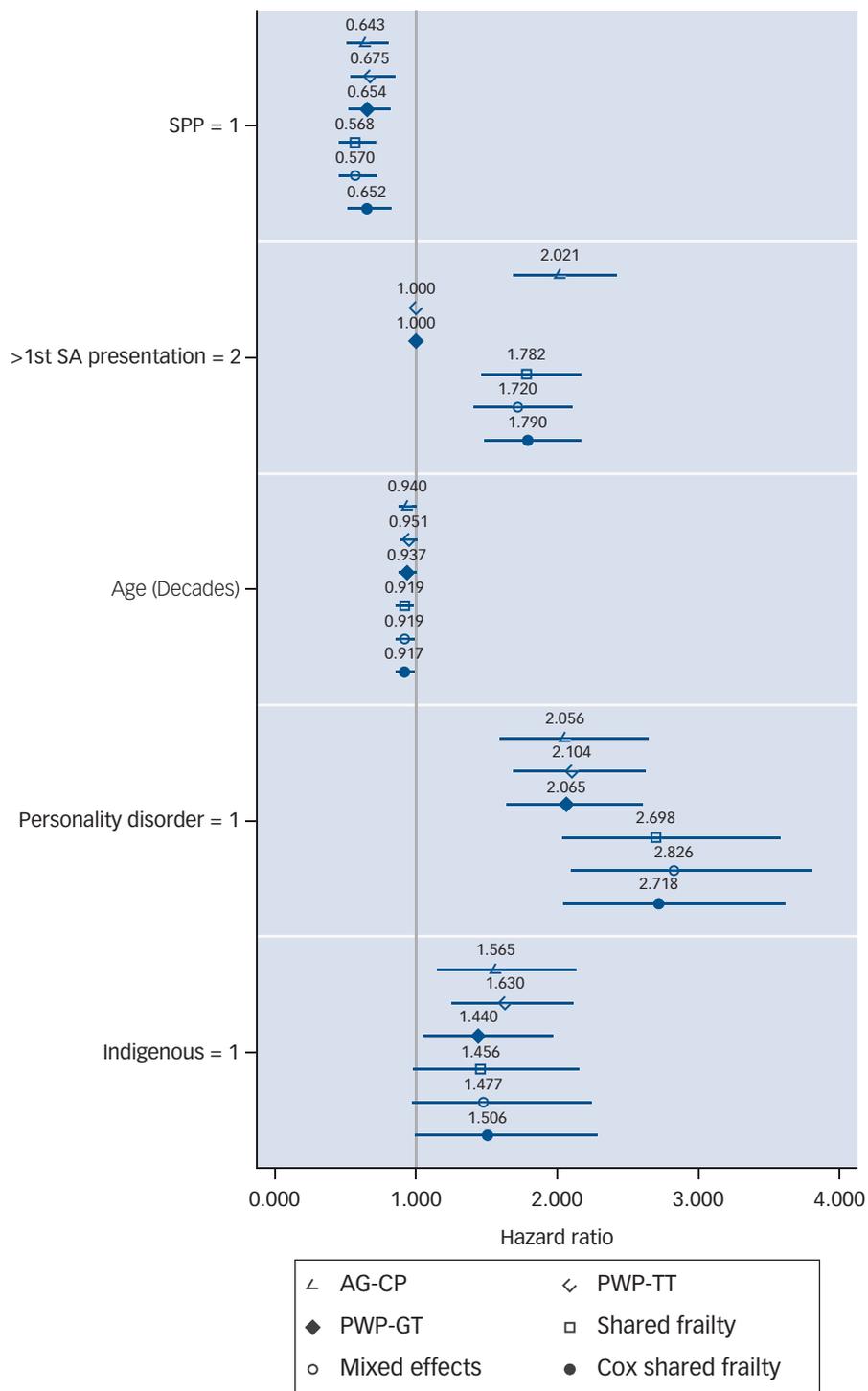a. Models shown are based on a truncation point of five suicide attempts.

Fig. 2 Hazard ratio estimates for each predictor variable in each model.

SPP, suicide prevention pathway; SA, suicide attempt; AG–CP, Anderson–Gill counting process; PWP–TT, Prentice–Williams–Petersen total time; PWP–GT, Prentice–Williams–Petersen gap time; shared frailty, Weibull gamma shared frailty; mixed effects, multilevel mixed effects parametric; Cox shared frailty, Cox proportional hazards shared frailty.

(>1st attempt) was also associated with an increased hazard, compared with first-time presenters (detected in four out of six models). Being Indigenous increased the hazard of a repeated suicide attempt presentation by approximately 1.5 times, compared with not being Indigenous. Increasing age by 10 years decreased the hazard of a repeated suicide attempt by approximately 5–8%.

Using the complete data-set, an interaction between SPP and >1st attempt was associated with an increased time to suicide attempt (HR = 1.6, $P = 0.036$). That is, there was a differentially greater effect of the SPP to increase time to suicide attempt re-presentation if the person was put on the SPP after their first suicide attempt presentation rather than after a subsequent presentation. The effect was similar in truncated data-sets (e.g. truncated at five presentations for the shared frailty model; HR = 1.5, $P = 0.095$) but was not included in the presented models (Table 3 and Fig. 2) because $P > 0.05$. For interest, however, its

effect, if included, is demonstrated in Fig. 3(b). No other interactions tested were found to be potentially important. The apparent lack of an SPP × personality disorder interaction (e.g. HR = 1.1, $P = 0.77$ for the shared frailty model) was of interest owing to the observation that people with a personality disorder were less likely to be placed on the SPP (Spearman rank correlation -0.40, $P < 0.001$), which may have been the result of clinical decision-making (see Discussion).

The relative relationships of factors influencing time to repeated suicide attempt are shown in Fig. 3. Different levels of each predictor
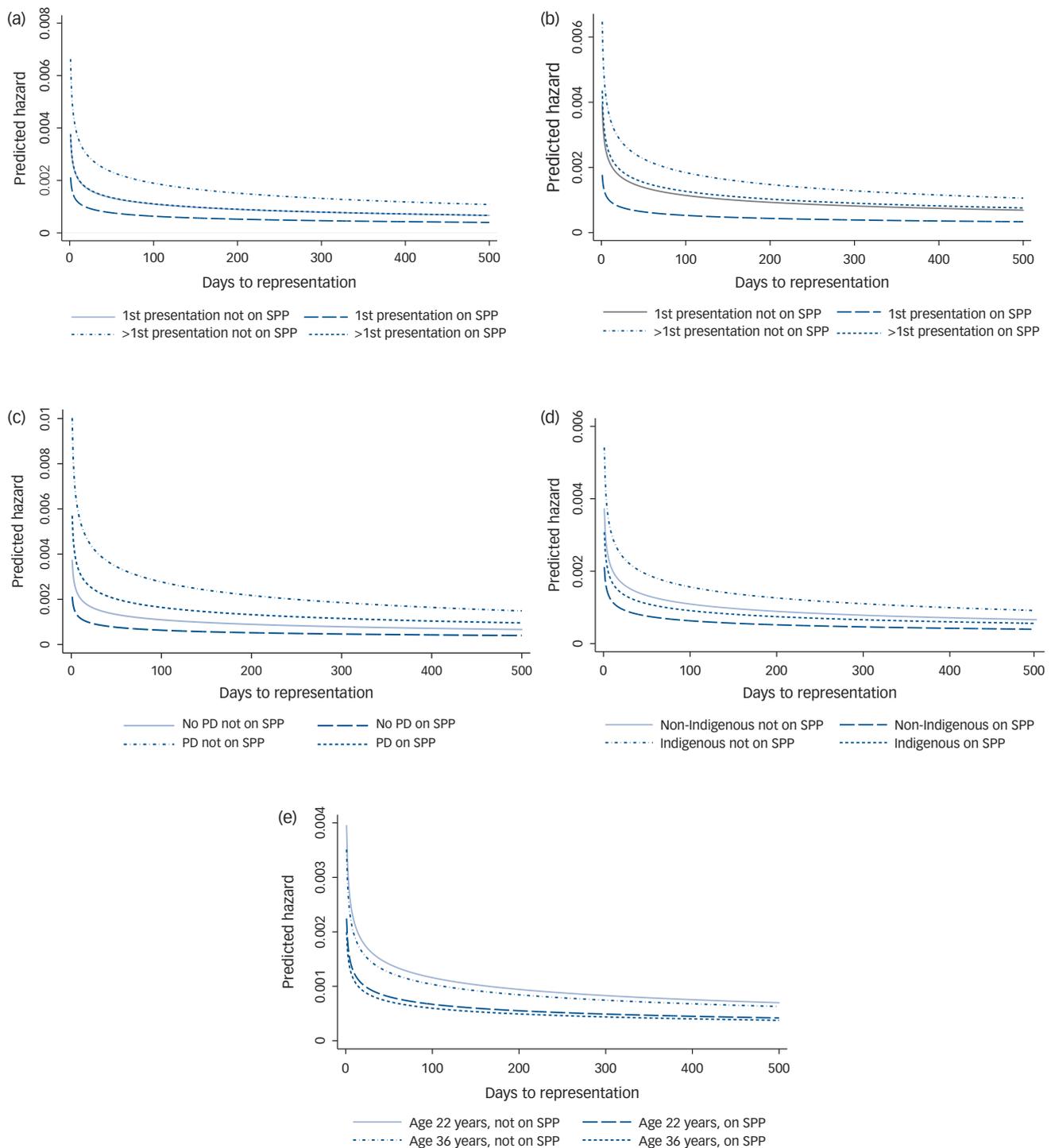
Fig. 3 Population predicted hazards based on the Weibull gamma shared frailty model.

(a) Effect of the suicide prevention pathway (SPP) and first or subsequent suicide attempt (SA) presentations for a non-personality disorder, non-Indigenous, 29-year-old (50th centile) individual. The curves for 1st presentation not on the SPP and >1st presentation on the SPP are superimposed. (b) Effect of the SPP and first or subsequent suicide attempt presentations when an SPP × 1st presentation interaction ($P = 0.095$) was included in the model. Hazards are shown for a non-personality disorder, non-Indigenous, 29-year-old individual. (c) Effect of the SPP and diagnosis of personality disorder (PD) for a 1st presentation, non-Indigenous, 29-year-old individual. (d) Effect of the SPP and Indigenous status for a 1st presentation, non-personality disorder, 29-year-old individual. (e) Effect of the SPP and age (22 years, 25th centile; or 36 years, 75th centile) for a 1st presentation, non-personality disorder, non-Indigenous individual.

variable are shown along with being placed on the SPP or not. These graphs also demonstrate how the hazard for a repeated suicide attempt decreases rapidly as the time from the previous attempt increases. Figure 3(a) shows that being placed on the SPP is essentially equivalent to the suicide attempt event being the first for an individual rather than a subsequent attempt (as is indicated by the curves being virtually superimposed). As noted earlier, the effect of an interaction between SPP and >1st attempt is shown in Fig. 3(b). Compared with Fig. 3(a), the curve for 1st presentation resulting in placement on the SPP is lower and the curve for >1st presentation resulting in placement on the SPP is higher, indicating that the SPP has a greater beneficial effect if applied at the first suicide attempt.

Being Indigenous and presenting with >1st attempt were positively correlated with a diagnosis of personality disorder (Spearman rank correlation 0.33, $P < 0.001$, and 0.24, $P < 0.001$ respectively). However, the variance inflation factors of 1.3 (SPP), 1.4 (personality disorder), 1.2 (Indigenous status) and 1.1 (>1st attempt) do not suggest that these correlations would unduly affect the HR estimates.

It should be noted that the effect of each predictor variable on time to a repeated suicide attempt is proportionally additive with the effects of other predictors in the model. This means that being on the SPP will reduce the hazard for a repeated suicide attempt equally in proportion for any individual. For example, being placed on the SPP will reduce the hazard to about 65% of the original hazard whether the presenting individual is an Indigenous person, a young person, a person with personality disorder or none of these.

Discussion

The Zero Suicide framework has gained international momentum in recent years while at the same time drawing criticism due to the lack of robust evidence-base supporting its effectiveness.[1,6] In this paper we demonstrate a significant reduction in risk of repeated suicide attempts to approximately 65% of a natural risk in patients receiving a suite of interventions following the Zero Suicide framework.

Significant reductions in suicide attempt re-presentation rates were seen within 7, 14, 30 and 90 days after the initial attempt for people on the SPP compared with those not on the SPP. Being on the SPP was shown to be particularly efficacious in the first 14 days, which is probably due to the average duration of placement on the SPP being around 16 days, during which time the patient remains in active contact with the health service through face-to-face appointments. However, the continued effectiveness of the SPP after this period suggests a sustained effect of the suite of interventions delivered during those first 2 weeks. We note that the rates of repeated suicide attempts at 90 days were relatively high in both groups, compared with an average of 16% reported in earlier systematic reviews.[11,34] The discrepancy could be partly explained by the limitations of the utilised project design; Owens et al[11] showed that low-quality studies showed more dispersed values around a higher median than high-quality studies (21 v. 15% repetition rates). Additional factors may be the use of presentation-based rather than person-based analysis, and the high levels of sensitivity in detecting suicide attempts in hospital administrative data through the use of a machine learning algorithm in our work.[26,35]

Time-to-recurrent-event analysis was used to model the effect of the SPP and other covariates on time to re-presentation with a suicide attempt. Irrespective of the model used, results showed that being placed on the SPP led to a longer time to re-presentation compared with those not placed on the SPP. In addition, we were also able to show that people diagnosed with a personality disorder, Indigenous people, those presenting with their second or subsequent suicide attempt as opposed to their first, and younger

people were associated with higher HRs, indicating an increased risk of re-presentation. This aligns with literature identifying Indigenous persons,[36] people diagnosed with personality disorder (especially borderline personality disorder)[21,22] and those with multiple past suicide attempts[20,37] as having a heightened risk for suicide attempts.

The effects of the SPP act proportionately in reducing hazards for suicide attempt re-presentation for all patient groups in the study. For example, a person diagnosed with a personality disorder benefits proportionately from being placed on the SPP, as their hazard is reduced to 65% of their original hazard, and the hazard for a person not diagnosed with personality disorder is also reduced to 65%, even though the former begins with a higher natural hazard. This finding has an important practical implication as it was observed that people diagnosed with personality disorder were less likely to be placed on the SPP, possibly because clinicians assumed that the SPP would be less effective. Suicide attempts in people with personality disorder are frequently perceived to be communicative gestures or ambivalent in intent.[22,38] As there was no SPP × personality disorder interaction, the SPP was seen to be equally effective in those with a diagnosis of personality disorder. We strongly recommend that all patients with personality disorder presenting with a suicide attempt be placed on the SPP.

Our demonstration of the efficacy of the SPP in first-time presenters makes it imperative for services to identify vulnerable individuals who have not previously presented and provide assertive outreach and clinical interventions for them. Such action may involve strengthening partnerships with referral sources such as the primary care sector and non-government services and improving screening. Furthermore, we can help prevent first presenters from becoming multiple presenters (who have a higher natural hazard) by placing all first-time presenters on the SPP. This would ensure gaining the benefits of the SPP and of being a first-time presenter simultaneously and take advantage of the possibility that the SPP has a greater beneficial effect if applied at the first suicide attempt.

Finally, we note that our work shows a significant reduction in risk of repeated suicide attempt that is larger than for other studies that have previously evaluated the outcomes of individual aftercare interventions.[16,39] In this work, we measured the cumulative effect of a suite of interventions, which may act synergistically in terms of positive benefit, making comparison with studies of individual interventions challenging.

Limitations

This work focused on re-presentations with a suicide attempt as an indicator of the efficacy of the SPP. While there is a substantial relationship between the clinical profiles of suicide attempts, particularly those of high lethality, and deaths by suicide,[12] it is recognised that the definitive measure of the SPP effectiveness will be a reduction in deaths by suicide.

We could not identify whether a person who did not re-present during the follow-up period had died. Owing to the rarity of such instances, however, it is unlikely that these cases would contribute significantly to the observed difference in re-presentations. A data linkage project is planned to track the long-term outcomes of GCMHSS patients and hence measure the effect of placement on the SPP on deaths by suicide. Another limitation was that we were only able to detect people who presented or re-presented to the GCHHS catchment area. This has likely accounted for an under-enumeration of repeated suicide attempts, particularly given some estimates that less than 30% of people seek help at a hospital after engaging in suicidal behaviour.[40]

As this work employed an observational design involving implementation of the SPP in a functioning health service there was

obvious potential for 'cross-contamination' of elements of the SPP to treatment as usual. This might have occurred because clinicians used certain elements of the SPP in the treatment of patients not denoted as being placed on the SPP or because patients were placed on the SPP following a previous suicide attempt but not the current one. Further, some patients in the SPP group may not have completed all the elements of the SPP, particularly as the time frame from which the cohort of suicide attempt presentations was sourced (July to December 2017) was a relatively early period after the implementation of the SPP at GCMHSS in December 2016, and the desired fidelity to the full clinical protocol may have not yet been achieved. However, it should be noted that the above limitations related to potential cross-contaminations of the groups would tend to decrease the discriminating ability with respect to the effect of the SPP placement on repeat suicide attempts. As we still noted a beneficial effect of the SPP placement, we believe that this in fact enhances the reliability of our findings. At the same time, we acknowledge that the fact that this project tested for the effectiveness of the SPP as a suite of interventions, each exposed to a range of variables difficult to measure and subsequently control for, limits the potential for replicability of our findings in other contexts.

Although some of the measured differences in participants' characteristics are shown in Table 2, a further limitation is that not all differences in clinical and personal characteristics can be measured and accounted for. Furthermore, we are aware of the potential lack of accuracy of the diagnostic codes used by emergency department staff, particularly in identifying individuals with personality disorders.[41]

Finally, we acknowledge that the project design prevents making firm conclusions about the efficacy of the SPP, in that the observed relationships cannot be interpreted as causal. There is thus a requirement for future studies to use more robust designs to demonstrate causality, such as a randomised controlled trial (RCT). We note, however, that such designs might pose significant ethical challenges regarding randomisation and masking and would be challenging to implement pragmatically for evaluation of the SPP outcomes.

Future directions

It is hoped that the results of this work will inform the design and analysis of future evaluation studies in this field.

Future work might examine long-term trends in the balance between repeated suicide attempts, self-harm and death by suicide and how these are affected by the SPP. For example, among persons with a past suicide attempt, increased future presentations with suicidal ideation could, in fact, be indicative of improved help-seeking behaviour. It is therefore possible that placement on the SPP may result in a shift in the nature of subsequent presentations from more to less severe.

There are some indications that certain interventions that constitute key elements of the SPP may have particular 'protective' value in the long term (e.g. when safety planning is done well, in particular if it includes the family).[42] Assessing individual contributions of the elements of the SPP, including the effect of increased clinician time with patients or exposure to elements of other evidence-based interventions received during their engagement with the mental health service, remains a goal for future work. This is especially important because different services might implement different clinical assessment tools or interventions as part of a Zero Suicide framework. Method and lethality of suicide attempt is another area of interest, as some literature indicates that these have a differential impact on the frequency of subsequent suicidal behaviours.[43]

With many hospital and health services across Australia, and globally, adopting the Zero Suicide framework, a key recommendation is that a robust evaluation, including quantitative analysis

methods used here, be incorporated as an integral component of a clinical pathway implementation. Future work should pivot to examining changes in rates of death by suicide as well as suicidal presentations and, if possible, adopt a design that can establish causal relationships between clinical service changes and these rates. Such work would require an all-of-services approach in a given region, including working with primary care providers and non-governmental service providers.

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Supplementary material

Data availability

This study used data collected at Gold Coast Mental Health Specialist Service as part of clinical practice and used in the evaluation of its suicide prevention strategy.

Author contributions

Declaration of interest

References

1 Mokkenstorm JK, Kerkhof AJFM, Smit JH, Beekman ATF. Is it rational to pursue zero suicides among patients in health care? *Suicide Life Threat Behav* 2017; **48**: 745–54.

2 Brodsky BS, Spruch-Feiner A, Stanley B. The zero suicide model: applying evidence-based suicide prevention practices to clinical care. *Front Psychiatry* 2018; **9**: 33.

3 Hogan MF, Grumet JG. Suicide prevention: an emerging priority for health care. *Health Aff (Millwood)* 2016; **35**: 1084–90.

4 Coffey C. Pursuing perfect depression care. *Psychiatr Serv* 2006; **57**: 1524–6.

5 Covington DW, Hogan MF. Zero suicide: the dogged pursuit of perfection in health care. *Psychiatr Times* 2019; **36**: 16–7.

6 Coyne JC. An open-minded, skeptical look at the success of "zero suicides": any evidence beyond the rhetoric? *Coyne of the Realm* 2016 (https://www.coyneoftherealm.com/2016/10/28/an-open-minded-skeptical-look-at-the-success-of-zero-suicides-any-evidence-beyond-the-rhetoric/).

7 Hampton T. Depression care effort brings dramatic drop in large HMO population's suicide rate. *JAMA* 2010; **303**: 1903–5.

8 Baker ST, Nicholas J, Shand F, Green R, Christensen H. A comparison of multi-component systems approaches to suicide prevention. *Australas Psychiatry* 2018; **26**: 128–31.

9 Dekker S. *Just Culture: Restoring Trust and Accountability in your Organization*. CRC Press, 2018.

10 Turner K, Stapelberg NJ, Sveticic J, Dekker SW. Inconvenient truths in suicide prevention: why a Restorative Just Culture should be implemented alongside a Zero Suicide Framework. *Aust N Z J Psychiatry* 2020; **54**: 571–81.

11 Owens D, Horrocks J, House A. Fatal and non-fatal repetition of self-harm: systematic review. *Br J Psychiatry* 2002; **181**: 193–9.

12 Beautrais AL. Suicides and serious suicide attempts: two populations or one? *Psychol Med* 2001; **31**: 837–45.

13 Sands N, Elsom S, Colgate R, Haylor H, Prematunga R. Development and interrater reliability of the UK Mental Health Triage Scale. *Int. J. Ment. Health* 2016; **25**: 330–6.

14 Shea SC. *The Practical Art of Suicide Assessment: A Guide for Mental Health Professionals and Substance Abuse Counselors*. John Wiley & Sons, 1999.

15 Pisani AR, Murrie DC, Silverman MM. Reformulating suicide risk formulation: from prediction to prevention. *Acad Psychiatry* 2016; **40**: 623–9.

16 Milner AJ, Carter G, Pirkis J, Robinson J, Spittal MJ. Letters, green cards, telephone calls and postcards: systematic and meta-analytic review of brief contact interventions for reducing self-harm, suicide attempts and suicide. *Br J Psychiatry* 2015; **206**: 184–90.

17 Stanley B, Brown GK. Safety planning intervention: a brief intervention to mitigate suicide risk. *Cogn Behav Pract* 2012; **19**(2): 256–64.

18 Daigle MS, Pouliot L, Chagnon F, Greenfield B, Mishara B Suicide attempts: prevention of repetition. *Can J Psychiatry* 2011; **56**: 621–9.

19 Beautrais A, Gibb SJ, Faulkner A, Mulder RT. 12: a randomized controlled trial of a brief intervention to reduce repeat presentations to the emergency department for suicide attempt. *Ann Emerg Med* 2008; **51**: P474.

20 Beautrais AL. Subsequent mortality in medically serious suicide attempts: a 5 year follow-up. *Aust N Z J Psychiatry* 2003; **37**: 595–9.

21 Schneider B, Wetterling T, Sargk D, Schneider F, Schnabel A, Maurer K, et al. Axis I disorders and personality disorders as risk factors for suicide. *Eur Arch Psychiatry Clin Neurosci* 2006; **256**: 17–27.

22 Gunderson JG, Ridolfi ME. Borderline personality disorder: suicidality and self-mutilation. *Ann N Y Acad Sci* 2001; **932**: 61–77.

23 Brent DA, Greenhill LL, Compton S, Emslie G, Wells K, Walkup JT, et al. The Treatment of Adolescent Suicide Attempters study (TASA): predictors of suicidal events in an open treatment trial. *J Am Acad Child Adolesc Psychiatry* 2009; **48**: 987–96.

24 Hawton K, Zahl D, Weatherall R. Suicide following deliberate self-harm: long-term follow-up of patients who presented to a general hospital. *Br J Psychiatry* 2003; **182**: 537–42.

25 Bennardi M, McMahon E, Corcoran P, Griffin E, Arensman E. Risk of repeated self-harm and associated factors in children, adolescents and young adults. *BMC Psychiatry* 2016; **16**(1): 421.

26 Stapelberg NCJ, Sveticic J, Hughes I, Turner K. Suicidal presentations to emergency departments in a large Australian public health service over 10 years. *Int J Environ Res Public Health* 2020; **17**(16): 5920.

27 De Leo D, Burgis S, Bertolote JM, Kerkhof AJ, Bille-Brahe U. Definitions of suicidal behavior: lessons learned from the WHO/EURO Multicentre Study. *Crisis* 2006; **27**: 4–15.

28 World Health Organization. *Practice Manual for Establishing and Maintaining Surveillance Systems for Suicide Attempts and Self-Harm*. WHO, 2016.

29 National Centre for Classification in Health. *The International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification (ICD-10-AM)*. National Centre for Classification in Health, 2004.

30 Amorim LD, Cai J. Modelling recurrent events: a tutorial for analysis in epidemiology. *Int J Epidemiol* 2015; **44**: 324–33.

31 Sagara I, Giorgi R, Doumbo OK, Piarroux R, Gaudart J. Modelling recurrent events: comparison of statistical models with continuous and discontinuous risk intervals on recurrent malaria episodes data. *Malar J* 2014; **13**: 293.

32 Schukken YH, Bar D, Hertl J, Gröhn YT. Correlated time to event data: modeling repeated clinical mastitis data from dairy cattle in New York State. *Prev Vet Med* 2010; **97**: 150–6.

33 Cleves M, Gould WW, Marchenko YV. *An Introduction to Survival Analysis Using Stata*. Stata Press, 2010.

34 Carroll R, Metcalfe C, Gunnell D. Hospital presenting self-harm and risk of fatal and non-fatal repetition: systematic review and meta-analysis. *PLoS One* 2014; **9**(2): e89944.

35 Sveticic J, Stapelberg NC, Turner K. Suicidal and self-harm presentations to Emergency Departments: the challenges of identification through diagnostic codes and presenting complaints. *Health Inf Manage J* 2020; **49**: 38–46.

36 Elliott-Farrelly T. Australian Aboriginal suicide: the need for an Aboriginal suicidology? *AeJAMH* 2004; **3**: 138–45.

37 Bergen H, Hawton K, Waters K, Cooper J, Kapur N. Psychosocial assessment and repetition of self-harm: the significance of single and multiple repeat episode analyses. *J Affect Disord* 2010; **127**: 257–65.

38 Soloff PH, Fabio A, Kelly TM, Malone KM, Mann JJ. High-lethality status in patients with borderline personality disorder. *J Pers Disord* 2005; **19**: 386–99.

39 Inagaki M, Kawashima Y, Kawanishi C, Yonemoto N, Sugimoto T, Furuno T, et al. Interventions to prevent repeat suicidal behavior in patients admitted to an emergency department for a suicide attempt: a meta-analysis. *J Affect Disord* 2015; **175**: 66–78.

40 De Leo D, Cerin E, Spathonis K, Burgis S. Lifetime risk of suicide ideation and attempts in an Australian community: prevalence, suicidal process, and help-seeking behaviour. *J Affect Disord* 2005; **86**: 215–24.

41 Howell SC, Wills RA, Johnston TC. Should diagnosis codes from emergency department data be used for case selection for emergency department key performance indicators? *Aust Health Rev* 2014; **38**: 38–43.

42 Stanley B, Brown GK, Brenner LA, Galfalvy HC, Currier GW, Knox KL, et al. Comparison of the safety planning intervention with follow-up vs usual care of suicidal patients treated in the emergency department. *JAMA Psychiatry* 2018; **75**: 894–900.

43 Runeson B, Tidemalm D, Dahlin M, Lichtenstein P, Långström N. Method of attempted suicide as predictor of subsequent successful suicide: national long term cohort study. *BMJ* 2010; **341**: c3222.