Trajectories of Service Contact before Suicide in People with Substance Use Disorders – A National Register Study

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ABSTRACT

Objective

This study aimed to identify trajectories of service use during the last year before suicide death and the characteristics associated with the trajectories in patients with substance use disorders.

Methods

This study used a national registry data linkage, which included all patients with substance use disorders who died by suicide in Norway between 2010 and 2018. In- and outpatient contacts with mental health or substance use services during the last year before suicide death was analyzed by week using Sequence State Analysis and cluster analysis to identify trajectories. Logistic regression was used to measure the association between the characteristics and the trajectories.

Results

We identified four trajectories of service contact. A brief contact trajectory (n = 366) with a low proportion of weeks in contact (M weeks = 8.3), associated with less psychosis or bipolar disorder (aOR = 0.13 (0.08-0.21)) and higher age. A regular contact trajectory (n = 160), with a higher proportion of contact (M weeks = 47.9), associated with psychosis or bipolar disorder (aOR = 3.66 (2.10-6.47)) and depressive or anxiety disorder (aOR = 3.11 (1.93-5.13)). An intermittent contact trajectory (n = 195) with most contacts with outpatient substance use disorder services (M weeks = 16.5). A continuous contact trajectory (n = 109) with a high proportion of inpatient contact (M weeks = 44.5), strongly associated with psychosis or bipolar disorder (aOR = 6.08 (3.26-11.80)).

Conclusion

Longitudinal descriptions of service use reveal different trajectories that are important to consider when developing policies or interventions to reduce the risk of suicide death in patients with substance use disorders.

Keywords: Suicide, Substance Use Disorders, State Sequence Analysis, Mental Health Services, Substance Use Disorder Services

INTRODUCTION

Substance use disorders (SUDs), including both Alcohol Use Disorders (AUD) and Drug Use Disorders (DUD), are associated with a substantially increased risk of death by suicide (Chai et al., 2022; Crump, Sundquist, et al., 2021; Heiberg et al., 2018; Too et al., 2019; Wilcox et al., 2004). The association between SUDs and suicide death is complex and influenced by additional factors such as depressive symptoms or personality traits, for example impulsivity (Conner & Ilgen, 2016). Despite the strong risk, however, knowledge to support suicide prevention for individuals with SUDs is currently limited (Mann et al., 2021; Padmanathan et al., 2019) – leaving a knowledge gap concerning an important cause of mortality in this group.

A large proportion of people with SUD who later die from suicide were in contact with services during the last year before suicide death (Crump et al., 2020; Crump, Kendler, et al., 2021). Such service use before suicide death is associated with increased use of in- and outpatient SUD services (Ahmedani et al., 2019), prevalent contact with mental health services (Ilgen et al., 2012; Myhre et al., 2020; Pirkola et al., 1999), and an increased risk of suicide death in people who received mental health treatment during the past year (Hesse et al., 2020). Moreover, suicide risk was found to be significantly increased for SUD patients who were admitted to inpatient psychiatric services with comorbid bipolar disorder or unipolar depression (Levola et al., 2022). Previous studies of contact with mental health or SUD services before suicide death have measured contact with services dichotomously, typically distinguishing broadly between contact or no contact with services within a certain period before death by suicide (Ilgen et al., 2012; Myhre et al., 2020; Pirkola et al., 1999; Walby et al., 2018). While common in the literature (Hom et al., 2015), such dichotomization does not take account of the number, variability, or sequence of contacts. When examining service use longitudinally, different latent classes of contact with SUD services emerge,

which were characterized by disengagement or classes separated by services contacted (Crable et al., 2021). Moreover, these classes were associated with predictors such as gender, age, and type of substance use.

More detailed and longitudinal descriptions, capturing a broader spectrum of service use in specialized SUD and mental health services, could contribute by describing the variation in patterns of service use and how they may be associated with treatment outcomes (Hom & Stanley, 2021), which could have implications for the development of suicide prevention strategies. State sequence analysis (SSA) is a method from the social sciences that is well suited to analyze longitudinal sequences of categorical data. SSA has recently been used for studies of psychiatric disability retirement (Pirkola et al., 2020), antipsychotic utilization trajectories (Brodeur et al., 2022), and healthcare utilization (Vanasse et al., 2020). An advantage of SSA is its ability to display service use as individual sets of continuous sequences, rather than discrete entities such as dichotomized measures of contact. Through the use of SSA we, thus, aimed to identify trajectories of service use in SUD patients over the last year before suicide death and to study what characterizes these trajectories in terms of individual characteristics.

METHODS

Sample

The study linked data from the Norwegian Cause of Death Registry (NCDR) (Norwegian Institute of Public Health, n.d.) and the Norwegian Patient Registry (NPR) (The Norwegian Directorate of Health, n.d.) using the unique 11-digit Norwegian person identifiable number to link data between the registries. First, information on all suicide deaths based on ICD-10 codes (X60-X84; Y10-14; Y872) (WHO, 2019, p. 10) in Norway between 2010 and 2019 was retrieved from the NCDR. Then, these individuals were linked with the NPR, and persons that had contact with mental health services, SUD services, or private mental health specialists during the last year before the date of death in the NPR were identified. The total linkage contained 2 685 patients. In Norway, SUD services are organized as separate interdisciplinary specialized health care services that constitute an entire chain of treatment for SUDs and psychiatric comorbidity. Lastly, we extracted all patients with an ICD-10 diagnosis of SUD (F10-F17; F18-F19) who received specialized SUD- or mental health services during the last year before suicide death.

For the patients included, from the NPR we extracted all episodes of direct contact (i.e. being physically present). Episodes with liaison psychiatric contacts (n = 307) were removed since liaison psychiatric services are reported differently to the NPR across health trusts; this resulted in the exclusion of nine people from the final sample. The final sample, thereby consisted of 830 patients with 14 655 episodes of contact with services during their last year before suicide death.

Design

The design of this study is a historical prospective case series based on a nationwide registry linkage.

Data sources

The NCDR contains information about cause of death for all deaths in Norway. The registry coverage is very high (> 98%), and the classification of suicide deaths is good (Pedersen & Ellingsen, 2015; Tøllefsen et al., 2015). The occurrence of unspecific or undetermined codes (Y10-34) for the underlying cause of death was very low in this material (*n* = 15; 0.01%).

The NPR includes information about contact with the health services in Norway. The NPR contains direct person identifiable data as from 2008 for mental health services and 2009 for SUD services. The registry contains information of contact with specialized health services and ICD-10 diagnostic codes for these episodes of contact. The completeness of valid personal IDs in the NPR is > 99% from 2010 and onwards for publicly funded mental health services and substance use disorder services (The Norwegian Patient Registry [Norsk pasientregister]], 2011). While the majority of SUD treatment in Norway is indeed publicly funded, and thus included in the NPR, some private treatment of AUD does exist. The magnitude is difficult to estimate but the overall number of patients in private treatment is very small compared to publicly funded services.

Variables

Date of death, method of suicide death, gender, and age were retrieved from the NCDR. Method of suicide death was collapsed into the three categories of ‘hanging or strangulation’ (X70), ‘poisoning’ (X60-X67), and ‘other methods’ (X68-X69, X71-X82, Y10-Y14, and Y87.2). Age was divided into 10-year groups.

Service contact is the primary outcome of this study and we calculated the variable for each case starting from the date of death and recorded weeks in treatment during the preceding year. The variable contains the levels ‘inpatient SUD services’, ‘inpatient mental

health services', 'outpatient SUD services', 'outpatient mental health services', and 'no contact with SUD or mental health services' distributed by week, allowing us to differentiate between mental health and substance use services and in- and outpatient contacts.

We grouped diagnoses into 'alcohol use disorders' (AUD) (F10) and 'drug use disorders' (DUD) (F11-16, F18-19) using the last-registered ICD-10 diagnosis of a substance use disorder. Psychiatric comorbidity was measured using the last episode registered with a non-SUD ICD-10 psychiatric diagnosis (F20-F91). We collapsed these diagnoses into the three categories of 'psychosis or bipolar disorder' (F20-F29, F30-F31), 'depressive or anxiety disorder' (F32-F48), and 'other psychiatric disorders' containing diagnoses from the F-chapter of ICD-10 not previously specified. Direct emergency care episodes of somatically treated deliberate self-harm where the individual was discharged as alive were retrieved from the somatic datasets in the NPR, using the X6n ICD-10 code for deliberate self-harm. The Charlson Comorbidity Index (Charlson et al., 1987) was estimated using data from the NPR to examine somatic comorbidity, using it as a categorical variable with the levels of 0, 1-2, and 3 or more.

Analysis

First, we analyzed the data using SSA (Abbott, 1995), using weeks with service contact during the year before the week of death as the unit of time, with an optimal matching algorithm (Abbott & Tsay, 2000). Weeks between inpatient admission and discharge were filled into the data to generate a full sequence of admission weeks. Since several service contacts could occur within the same week, we ranked the variables hierarchically in the following order: 'inpatient SUD services', 'inpatient mental health services', 'outpatient SUD services', 'outpatient mental health services', and 'no contact'. This ranking process for the contacts removed 7 149 episodes of contact within the same week.

Next, we used cluster analysis to identify trajectories of contact patterns before suicide death using an agglomerative nesting algorithm (AGNES) (Kaufman & Rousseeuw, 1990). AGNES is a hierarchical nesting algorithm, where each sequence starts as its own cluster. Clusters were then merged until they were all combined into one cluster. The number of clusters was determined by examining the height of consecutive steps in the dendrogram (Appendix A) and the interpretability of clusters. An advantage of an unsupervised algorithm is that less prior assumptions are necessary.

Service use was analyzed by visually inspecting individual contact patterns and by estimating the mean percentage of weeks spent in each state of contact and any contact by trajectory. The distribution of covariates was described by cluster and tested with Chi-squared tests. Associations between clusters and covariates were examined through bi- and multivariate logistic regression models comparing each trajectory to the remaining trajectories. We tested whether the covariates differed between clusters by comparing the coefficients of the multivariate models, and we used modified Bonferroni corrections to adjust for non-independent multiple tests (Holm, 1979). This part of the procedure was a minor deviation from the preregistration. We considered using multinomial logistic regression as an alternative analytic strategy, but since this would render the interpretation of any differences between clusters difficult, we chose to compare clusters one by one. Lastly, we conducted post-hoc analyses whereby we examined days from the last contact to suicide death by trajectory. Kaplan-Meier survival curves were estimated and we used log-rank tests to test the differences in days from the last contact until death by suicide. The analysis was preregistered at the Open Science Framework (osf.io/wmrxb). The R packages *TraMineR* (Gabadinho et al., 2011), *cluster* (Maechler et al., 2019), *survival* (Therneau, 2021), and *survminer* (Kassambara et al., 2021) were used to analyze the data in R version 4.0.3 (R Core Team, 2021).

Ethics and approvals

This study was approved by the Regional Committees for Medical and Health Research Ethics South-East Norway (reference: 32494). Since this study included participants retrospectively, informed consent was impossible to retrieve and the project has an explicit exemption from the Norwegian Directorate of Health concerning patient confidentiality rules (reference: 16/27835-12).

RESULTS

Within the total sample of 830 patients who had contact with mental health or SUD services last year and who were registered with a SUD diagnosis, we identified four trajectories of service use during the last year before suicide death. Trajectory 1, labeled *brief contact*, included 366 people who died by suicide. Trajectory 2, *regular contact*, included 160 people, while trajectory 3, *intermittent contact*, included 195 people. Trajectory 4, *continuous contact*, included 109 people. Further characteristics of the participants by trajectory are described in Table 1.

The individual sequences within clusters are displayed in Figure 1. The *brief contact* trajectory was characterized by few overall and successive contacts distributed across the year before the suicide death, with 91.7 % of the week's spent without contact (Table 2). Outpatient SUD services (*Mean* = 2.5 %) and inpatient MHS (*M* = 2.5 %) were the most prevalent services used. The second trajectory, *regular contact*, had a service use pattern with contact approximately every other week throughout the year. Contact with inpatient SUD services (*Mean* = 8.5 %) was slightly less prevalent than contact with the other sectors in this trajectory. As shown in panel 2 in Figure 1, service use, especially of inpatient mental health services, increased towards the week of the death by suicide in the *regular contact* trajectory. The third trajectory, *intermittent contact*, was characterized by a contact level in-between the brief contact and regular contact trajectory. Outpatient SUD services (*Mean* = 9.7 %) were the most prevalent service used in this cluster, but service contact was scattered across all types of services with few extended sequences of contact. This trajectory also contains few long contact sequences and fewer contacts in the last weeks before the suicide death. The fourth trajectory, *continuous contact*, contains nearly continuous contact with services during the last year before the suicide death. It mostly contains long inpatient admissions in MHS and the

time spent on this type of contact is almost double the mean time spent on the other types of service contacts (*Mean* = 30.0 %). Kaplan-Meier survival curves of the number of days from the last contact to death by suicide by trajectory are shown in Figure 2. There was a significant overall difference between clusters in the number of days from the last contact to suicide death ($x^2 = 240$, $p = < 0.001$). Median days from the last contact were 55 days (95 % CI 45-71 days) in the *brief contact trajectory*, 7 days (95 % CI 5-10 days) in the *regular contact trajectory*, 16 days (95 % CI 10-23 days) in the *intermittent contact trajectory* and 4 days (95 % CI 2-6 days) in the continuous contact *trajectory*.

Overall, clusters differed with respect to distribution by gender ($p = < 0.001$), age groups ($p = 0.002$), and psychiatric comorbidity ($p = < 0.001$). Members of the *brief contact trajectory* differed from the other clusters by having reduced odds of being female (aOR = 0.55 (0.40-0.74)), 45-54 years old (aOR = 2.18 (1.45-3.28)) and more than 55 years old (aOR = 2.21 (1.45-3.28)) and decreased odds of psychiatric comorbidity, as shown in Table 3. For the *regular contact trajectory*, we observed increased odds of being female (aOR = 1.81 (1.27-2.58)), a diagnosis of psychosis or bipolar disorder (aOR = 3.60 (2.08-6.28)) and depressive or anxiety disorder (aOR = 3.11 (1.93-5.13)). Members of the *intermittent contact trajectory* had a decreased odds of being 45-54 years old (OR = 0.52 (95 % CI 0.31-0.86)) or being above 55 years old (OR = 0.53 (95 % CI 0.30-0.91)) and increased odds of having a depressive or anxiety disorder (OR = 1.75 (95 % CI 1.17-2.65)). These differences did not remain significant, however, after adjusting the p values. In the *continuous contact trajectory*, highly increased odds (aOR = 6.08 (95 % CI 3.26-11.8) of having a diagnosis of psychosis or bipolar disorder were observed, which was also significant in the adjusted analysis ($p = < 0.001$).

DISCUSSION

Behind the answer of "yes, had contact with services the last year", lies a myriad of service use possibilities. In this study of such contact in patients with SUDs who died by suicide, we identified four trajectories: brief, intermittent, regular, and continuous contact with services. Time from the last contact to suicide death differed between the *brief contact trajectory* and the other trajectories, in that the suicide death occurred significantly longer after the last contact in the *brief contact trajectory*. There were several important differences between trajectories in terms of how they were associated with covariates of interest; members of the *brief contact trajectory* were more to be likely men, of higher age, and less likely to have any form of psychiatric comorbidity. Members of the *regular contact trajectory* were more often women, and they were more likely to have any form of psychiatric comorbidity. In the *intermittent contact trajectory*, they were less likely to be of higher age, and more likely to have depressive or anxiety disorders, whereas the *continuous contact trajectory* had an increased likelihood of any form of psychiatric comorbidity – in particular psychosis or bipolar disorders.

The results from this study relates to previous findings in several respects. As found in previous studies that used SUD samples (Ilgen et al., 2012; Pirkola et al., 1999), contact with mental health services was prevalent the last year before death by suicide. Here, we were able to elaborate on previous findings by describing service use trajectories by week, which showed that mental health services were among the services most contacted in all the trajectories. The trajectories were also associated with different mental disorders. Suicide death was often preceded by service contact in individuals with alcohol use and drug use disorders (Crump et al., 2020; Crump, Kendler, et al., 2021). The timing of contact could also depend on previous service use, given the association between service use trajectories and time from last contact to suicide death observed in this study. Moreover, past year psychiatric

care of SUD patients is associated with increased risk of death by suicide (Hesse et al., 2020). In this study, the trajectories associated with psychiatric comorbidity – the regular, intermittent and continuous contact trajectories – were also associated with shorter time from contact to suicide death.. In addition, trajectories describe several service contact characteristics not previously described, as shown below.

Most subjects with SUDs who died by suicide only had brief contact with services during the last year. Here, the service use trajectories provide information about the variation in service which is lost when measuring contact dichotomously. Among these patients, suicide deaths occurred longer after the last contact than for the other trajectories, which may be perceived as inherent in the brevity of their contact with the services. Patients in this cluster were also more likely to be male and above 45 years of age and with a reduced rate of psychiatric comorbidity; all of which are characteristics associated with a reduced tendency to seek contact with services for substance use and mental health, according to previous studies (Pirkola et al., 1999; Walby et al., 2018). This cluster, constituting a large proportion of all patients in this study, illustrates an important challenge in suicide prevention for men with SUDs; how to effectively deliver suicide preventive interventions to patients who are disengaged from services. The literature on service utilization has focused mostly on barriers to service access (Hom et al., 2015), but other aspects such as treatment engagement (Lizardi & Stanley, 2010), or continuity of care, also warrant attention – especially in men.

In the second cluster, the regular contact cluster, members were more likely to be women and to have any type of psychiatric comorbidity. A strong association between psychiatric comorbidity and death by suicide in people with SUDs has been found in several previous studies (Hesse et al., 2020; Østergaard et al., 2017), and high service utilization is generally also associated with comorbid psychiatric disorders (Kessler et al., 1996). Psychiatric comorbidity is more prevalent and service use more frequent in women than men

(McHugh et al., 2017) both generally and before suicide death (Walby et al., 2018), which may contribute to explaining the multivariate association between both these variables in this trajectory. It may be the case that this regular contact pattern could reflect the patients' psychiatric treatment needs since this trajectory was so strongly associated with psychiatric comorbidity. Why such regular contact still ended in suicide death and how deaths in this group best could be prevented are important questions to resolve in future studies. Based on the strong associations uncovered here, integrated treatment of comorbid substance use and psychiatric disorders (Mueser et al., 2003), with a specific focus on female SUD patients' needs, seems to be a potential area of focus for prevention.

Members of the third trajectory, intermittent contact, had a relatively high proportion of contact with SUD services, especially outpatient services. The intermittent contact trajectory comprised fewer individuals from the oldest age groups, and service use was often scattered across several different types of services. Members of this cluster also had an increased prevalence of depressive and anxiety disorders, which is consistent with previous findings that service utilization by people with comorbid SUD and mood disorders tends to show use of fewer services before an index suicide attempt (Suominen et al., 2002). The stronger association with depressive or anxiety disorders could contribute to explaining why the suicide deaths in this cluster occurred sooner after contact (Hesse et al., 2020), while the overall service use in this cluster was lower since negative affectivity and depressive symptoms are important risk factors for death by suicide in people with SUDs (Conner & Ilgen, 2016). This could in turn imply a potential mismatch between services used and the severity of problems, which could be due to either patient or service characteristics. This is an issue in need of more research.

The continuous contact trajectory, characterized by patients with longer inpatient admissions and frequent outpatient contacts with both SUD and mental health services, was

strongly associated with psychiatric comorbidity. Associations were particularly strong for severe mental disorders such as psychotic or bipolar disorders. As pointed out above for the regular contact trajectory, it seems that service use was strongly associated with psychiatric comorbidity, with gender and age as moderating factors. This could indicate that this trajectory contains patients with more severe conditions and poor functioning, requiring intensive contact with services. While the continuous contact trajectory was the smallest, it does contain a substantial proportion of the overall service use in this study, including a large proportion of inpatient service use. It is reasonable to assume that the continuous contact trajectories could moderate current suicide risk, especially during inpatient admissions. This points to discharge as an important high-risk period even when service use is predominantly continuous, given the close temporal association between last contact and suicide death in this study and the well-documented risk of suicide after discharge from inpatient services (Chung et al., 2017).

Strengths and limitations

A strength of this study is its complete national capture by using a registry sample over a ten-year period, which reduces methodological problems linked to sampling biases. The large number of study subjects; people with SUD who were deceased by suicide allowed us to study suicide death as an outcome rather than proxy variables such as suicide attempt. We used a new statistical method, SSA, to analyze the services use trajectories, which enabled us to describe service use trajectories longitudinally and sequentially. SSA made it possible to illustrate the complexity of service use trajectories that lie inside previously dichotomized measures previously used (Ahmedani et al., 2019), which more closely represent the services used by these patients.

An important limitation of this study was that it is descriptive and uncontrolled. We are consequently unable to assess the suicide risk, or mediators or moderators of suicide risk

associated with these clusters. A general challenge when using cluster analysis is to determine the number of clusters. In this study we chose to use a conservative number of clusters, since increasing the number of clusters would make it increasingly difficult to differentiate clusters from each other. While we were able to differentiate between in- and outpatient contacts, we were unable to describe the type of treatment the individuals received, whether contact was with different providers, whether treatment was evidence-based or not, or whether contacts was prompted by suicidal behaviors, all of which are factors that it would have been important to describe. While results should be interpreted within a Norwegian clinical context, we consider the service use trajectory concept and study methodology to also be relevant for health systems in other countries.

Conclusions

This study provides a more detailed description of service contact patterns in SUD patients before their suicide death than previous studies have offered, which is thought have clinical implications for prevention and should lead to a rethinking of common approaches to treatment. A large proportion of individuals in the study were in the brief or intermittent contact trajectories, where the possibility of providing any evidence-based treatments seems, under such circumstances, unlikely. It illustrates a challenge in this population that needs to be accounted for when designing suicide prevention programs. Furthermore, it calls for the utilization of more active treatment engagement strategies. These trajectories illustrate that distinctive prevention strategies may be necessary for different groups within the heterogeneous population of SUD patients based on their connection to services. Descriptive studies, such as this one, may provide a basis for future controlled studies by identifying several areas of interest that need further examination.

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Disclosure statement

The authors have no conflict of interest to disclose.

Data availability statement

Data not available due to ethical and legal restrictions

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Table 1. Description of characteristics of people with substance use disorders who died by suicide after contact with services by contact pattern cluster.

	(1) Brief contact		(2) Regular contact		(3) Intermittent contact		(4) Continous contact			
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	x^2	*p*
n	366	44.1 %	160	19.3 %	195	23.5 %	109	13.1 %		
Gender									20.023	< 0.001
Men	272	74.3%	90	56.3%	130	66.7%	66	60.6%		
Women	93	25.4%	70	43.8%	65	33.3%	43	39.4%		
Age									31.108	0.002
17-24	34	9.3%	21	13.1%	21	10.8%	16	14.7%		
25-34	72	19.7%	42	26.3%	57	29.2%	34	31.2%		
35-44	75	20.5%	34	21.3%	56	28.7%	27	24.8%		
45-54	99	27.0%	33	20.6%	32	16.4%	19	17.4%		
55-	86	23.5%	30	18.8%	29	14.9%	13	11.9%		
Suicide method									6.213	0.400
Hanging or strangulation	154	42.1%	71	44.4%	89	45.6%	43	39.4%		
Poisoning	102	27.9%	55	34.4%	57	29.2%	30	27.5%		
Other means	110	30.1%	34	21.3%	49	25.1%	36	33.0%		
Substance use disorder									4.494	0.213
Alcohol use disorder (F10)	163	44.5%	63	39.4%	77	39.5%	37	33.9%		
Drug use disorder (F11-F16; F18-F19)	203	55.5%	97	60.6%	118	60.5%	72	66.1%		
Opiates (F11)	58	28.6%	13	13.4%	30	25.4%	21	29.2%		
Cannabinoids (F12)	34	16.7%	17	17.5%	21	17.8%	8	11.1%		
Sedatives and hypnotics (F13)	26	12.8%	20	20.6%	21	17.8%	9	12.5%		
Stimulants (F15)	15	7.4%	7	7.2%	16	13.6%	7	9.7%		
Other substances (F14. F16. F18)	5	2.5%	3	3.1%	1	0.8%	1	1.4%		

Multiple substances (F19)	65	32.0%	37	38.1%	29	24.6%	26	36.1%		
Psychiatric comorbidity									128.33	< 0.001
None	197	53.8%	27	16.9%	54	27.7%	16	14.7%		
Psychosis or bipolar disorder	28	7.7%	36	22.5%	34	17.4%	37	33.9%		
Depressive or anxiety disorder	102	27.9%	72	45.0%	79	40.5%	33	30.3%		
Other	33	9.0%	16	10.0%	23	11.8%	37	33.9%		
Deliberate self-harm last year									4.136	0.247
No	332	90.7%	139	86.9%	168	86.2%	93	85.3%		
Yes	34	9.3%	21	13.1%	27	13.8%	16	14.7%		
Charlson comorbidity index									2.264	0.894
0	247	67.5	112	70	131	67.2	69	63.3		
1-2	110	30.1	46	28.8	59	30.3	38	34.9		
>2	9	2.4	2	1.2	5	2.5	2	1.8		

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543 **Table 2**. Mean percentage of weeks spent in contact with different types of services the last year before suicide

	(1) Brief contact	(2) Regular contact	(3) Intermittent contact	(4) Continuous contact
Service contact	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Any contact	8.3 (5.0)	47.9 (7.5)	27.3 (5.7)	76.5 (11.5)
Inpatient	3.3 (3.3)	21.6 (15.0)	10.8 (9.2)	44.5 (25.8)
SUD services	0.8 (2.1)	8.5 (13.7)	4.1 (7.5)	15.0 (24.0)
Mental health services	2.5 (3.7)	13.1 (13.7)	6.8 (7.9)	30.0 (28.0)
Outpatient	5.0 (5.1)	26.2 (17.0)	16.5 (10.4)	32.0 (27.4)
SUD services	3.3 (4.7)	12.3 (17.6)	9.7 (11.6)	16.0 (26.0)
Mental health services	1.7 (3.4)	13.9 (15.9)	6.8 (8.5)	16.0 (23.0)
No contact	91.7 (5.0)	52.1 (7.1)	72.7 (5.7)	23.0 (12.0)

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Table 3. Bi- and multivariate associations between service use trajectories and characteristics in substance use disorder patients who died by suicide

	(1) Brief contact					(2) Regular contact					(3) Intermittent contact					(4) Continous contact				
	Crude		Adjusted			Crude		Adjusted			Crude		Adjusted			Crude		Adjusted		
	OR (95 % CI)	*p*	OR (95 % CI)	*p*	*p* adjusted	OR (95 % CI)	*p*	OR (95 % CI)	*p*	*p* adjusted	OR (95 % CI)	*p*	OR (95 % CI)	*p*	*p* adjusted	OR (95 % CI)	*p*	OR (95 % CI)	*p*	*p* adjusted
Gender																				
Male	1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)		
Female	0.55 (0.40-0.74)	**0.001**	0.60 (0.43-0.84)	**0.002**	0.019	1.81 (1.27-2.58)	**0.009**	1.66 (1.14-2.41)	**0.008**	0.084	1.04 (0.74-1.46)	0.816	1.02 (0.71-1.45)	0.931	1.000	1.41 (0.93-2.13)	0.105	1.25 (0.80-1.95)	0.324	1.000
Age																				
17-24	1.08 (0.65-1.80)	0.76	1.23 (0.71-2.13)	0.456	1.000	1.15 (0.63-2.06)	0.649	1.08 (0.58-1.98)	0.807	1.000	0.77 (0.43-1.35)	0.368	0.73 (0.40-1.30)	0.298	1.000	1.06 (0.54-2.01)	0.864	1.04 (0.51-2.02)	0.918	1.000
25-34	1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)		
35-44	1.18 (0.79-1.78)	0.417	1.37 (0.88-2.15)	0.163	0.977	0.84 (0.50-1.38)	0.482	0.76 (0.45-1.27)	0.296	1.000	1.07 (0.69-1.65)	0.764	1.05 (0.67-1.63)	0.842	1.000	0.82 (0.47-1.42)	0.486	0.75 (0.42-1.32)	0.318	1.000
45-54	2.18 (1.45-3.28)	**< 0.001**	2.61 (1.65-4.16)	**< 0.001**	**< 0.001**	0.85 (0.51-1.41)	0.541	0.82 (0.47-1.40)	0.464	1.000	0.55 (0.33-0.89)	**0.016**	0.52 (0.31-0.86)	**0.012**	0.134	0.58 (0.31-1.05)	0.078	0.59 (0.31-1.11)	0.109	0.875
55-	2.21 (1.45-3.38)	**< 0.001**	2.49 (1.53-4.12)	**< 0.001**	**0.002**	0.91 (0.54-1.53)	0.722	0.92 (0.51-1.65)	0.789	1.000	0.58 (0.35-0.96)	**0.037**	0.53 (0.30-0.91)	**0.023**	0.233	0.45 (0.22-0.87)	**0.021**	0.50 (0.23-1.04)	0.07	0.634
Suicide method																				
Hanging or strangulation	1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)		
Poisoning	0.91 (0.65-1.26)	0.566	0.84 (0.58-1.21)	0.345	1.000	1.14 (0.76-1.69)	0.528	1.06 (0.70-1.61)	0.774	1.000	0.89 (0.61-1.30)	0.546	0.93 (0.62-1.37)	0.701	1.000	1.23 (0.76-1.97)	0.397	1.39 (0.84-2.31)	0.198	1.000
Other means	1.28 (0.92-1.80)	0.146	1.17 (0.80-1.72)	0.409	1.000	0.72 (0.46-1.13)	0.159	0.67 (0.42-1.08)	0.106	0.846	0.85 (0.57-1.26)	0.416	0.95 (0.62-1.37)	0.804	1.000	1.14 (0.68-1.86)	0.619	1.30 (0.76-2.22)	0.336	1.000
Substance Use Disorder																				
Alcohol Use Disorder (F10)	1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)		

	0.77		1.04			1.09		0.99			1.08		0.92					1.12	
	(0.58-		(0.75-			(0.76-		(0.67-			(0.78-		(0.64-			1.41		(0.71-	
Drug Use Disorder (F11-16. F18-19)	1.01)	0.063	1.44)	0.813	1.000	1.55)	0.649	1.47)	0.971	1.000	1.51)	0.632	1.31)	0.644	1.000	(0.93-2.17)	0.111	1.79)	0.631	1.000
Psychiatric comorbidity																				
No comorbidity	1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)		
	0.13		0.13			3.60		3.66			1.50		1.37			6.55		6.08		
	(0.08-	<	(0.08-			(2.08-	<	(2.10-	<		(0.91-		(0.83-			(3.55-	<	(3.26-	<	
Psychosis or bipolar disorder (F20-F31)	0.21)	**0.001**	0.22)	**< 0.001**	**< 0.001**	6.28)	**0.001**	6.47)	**0.001**	**< 0.001**	2.43)	0.106	2.25)	0.21	1.000	12.62)	**0.001**	11.80)	**0.001**	**< 0.001**
	0.27		0.27			3.32		3.11			1.70		1.75					2.19		
Depressive or anxiety disorder (F32-	(0.19-	<	(0.19-			(2.09-	<	(1.93-	<		(1.15-		(1.17-			2.27		(1.18-		
F48)	0.38)	**0.001**	0.39)	**< 0.001**	**< 0.001**	5.44)	**0.001**	5.13)	**0.001**	**< 0.001**	2.52)	**0.008**	2.65)	**0.006**	0.082	(1.24-4.32)	**0.009**	4.23)	**0.015**	0.015
	0.25		0.34			2.75		2.25			1.43		1.29					3.61		
	(0.16-	<	(0.21-			(1.51-		(1.20-			(0.84-		(0.74-			4.35	<	(1.78-	<	
Other comorbidity (F50-F90)	0.40)	**0.001**	0.55)	**< 0.001**	**< 0.001**	4.98)	**0.008**	4.20)	**0.010**	0.096	2.39)	0.176	2.21)	0.368	1.000	(2.22-8.71)	**0.001**	7.48)	**0.001**	0.005
Somatically treated deliberate self-harm																				
No	1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)		1 (ref)			1 (ref)				
	0.64		0.83			1.16		0.91			1.28		1.20					1.15		
	(0.16-		(0.51-			(0.68-		(0.52-			(0.78-		(0.73-			1.34		(0.61-		
Yes	0.40)	**0.047**	1.34)	0.457	1.000	1.92)	0.566	1.54)	0.743	1.000	2.03)	0.314	1.95)	0.46	1.000	(0.73-2.33)	0.32	2.08)	0.642	1.000

Note: The adjusted analysis is adjusted for all other variables. P values are adjusted using modified Bonferroni correction. Significant values are marked with bold numbers.

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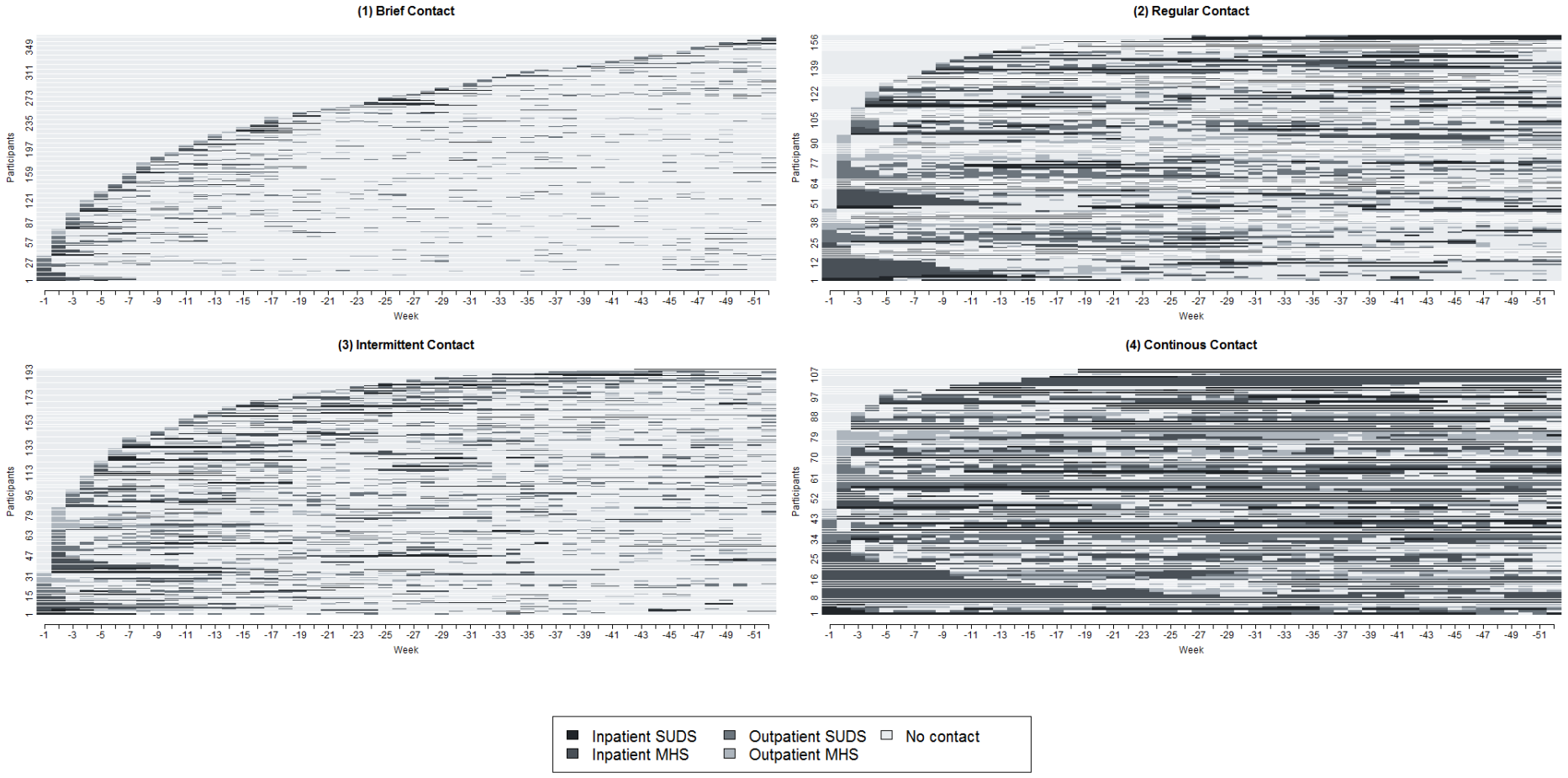
548 **Figure captions**

549 **Figure 1.** The sequences of service use last year for individuals by cluster for all participants. The x-axis illustrates weeks from the suicide where
550 the far left is the week of the suicide. The filled horizontal bars displays contact with services. Participants are displayed on the y-axis, which is
551 sorted by the start of the sequences.

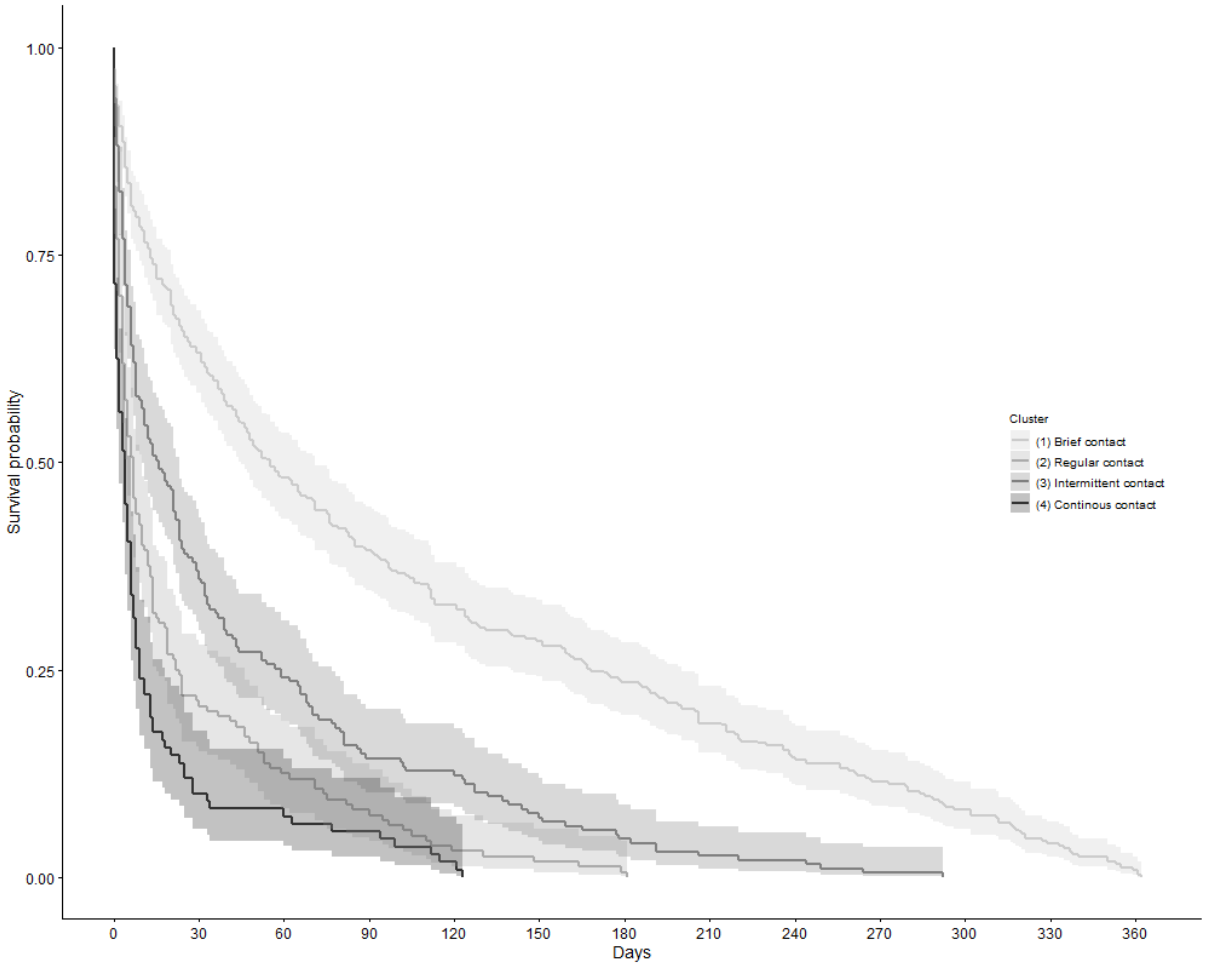
552 **Figure 2.** Kaplan-Meier survivals curves for days from last contact to the suicide by cluster. Shaded area around the lines illustrate the 95 %
553 confidence intervals.

554

Figure 1


(1) Brief Contact
(2) Regular Contact
(3) Intermittent Contact
(4) Continous Contact
Participants
Week
Inpatient SUDS
Inpatient MHS
Outpatient SUDS
Outpatient MHS
No contact

558 **Figure 2**



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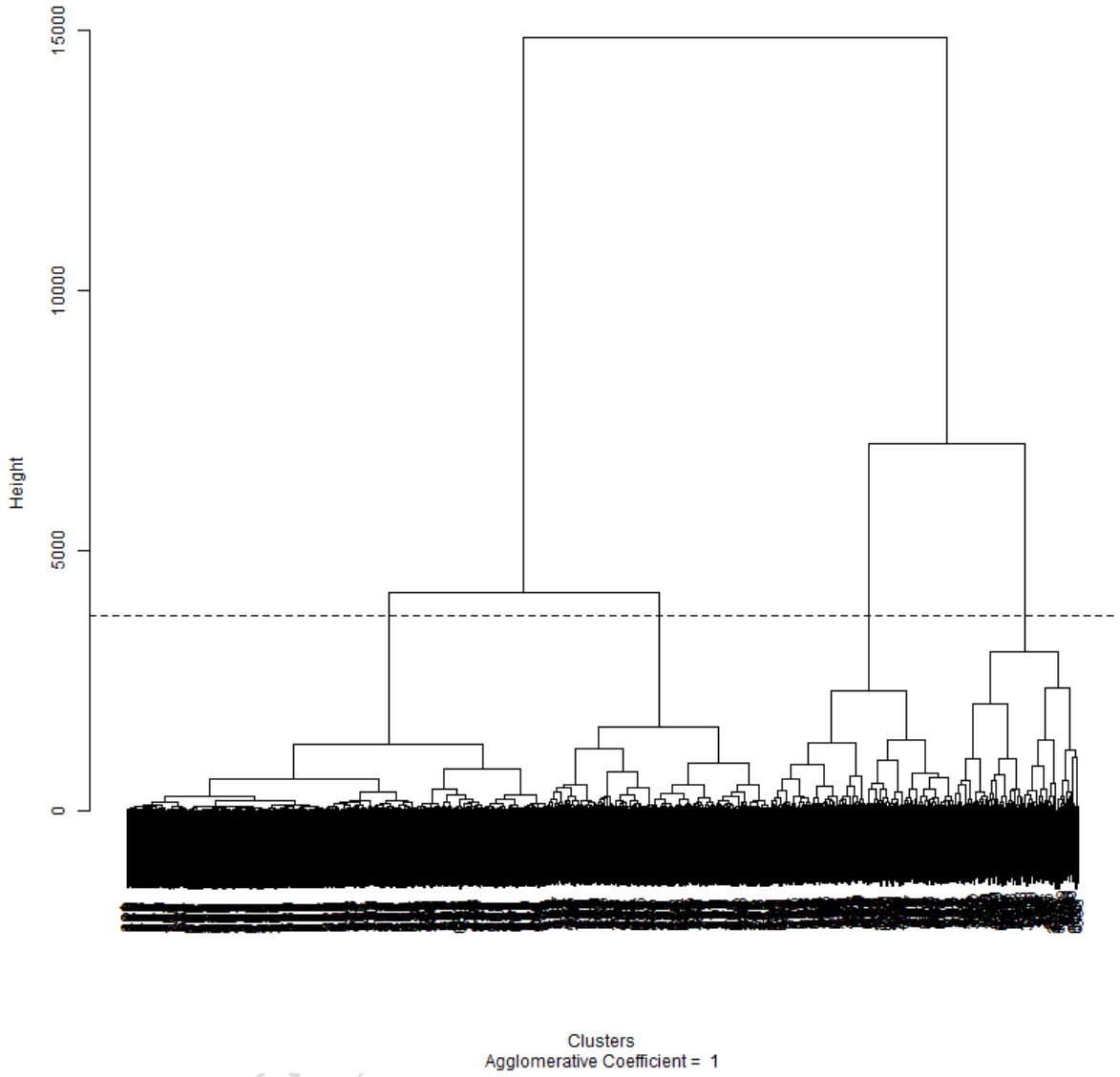

Appendix A. Dendrogram illustrating the agglomerative hierarchical clustering algorithm. The dashed horizontal line illustrates where the clusters are cut.